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Foreword

ELECTRONICS has played a key role in the world's dynamic technological progress during the twentieth century. As the last decade of this century begins, electronics will increase that role through a host of new and improved products and services.

The cover of the *1991 Electronic Market Data Book* emphasizes *globalization*, the key term for the decade of the '90s. The electronics industries are increasing their impact on planet earth while the insatiable quest for worldwide information leads to more communication and standardization across the globe. As you read this year's volume, you will notice increased interaction and overlap between the various industry segments. As the world's information society becomes more homogenous, the electronic components are beginning to follow the trend. Electronics as a whole are now weaving their way into more and more facets of the world community! In keeping with the world theme and emphasizing the 1991 current environmental concerns, this book is printed on recycled paper for the first time.

The impact of the electronic industries on the U.S. economy can be measured in several ways:

- U.S. shipments of electronic products were up nearly 5% in 1990 to a total of $266 billion.
- U.S. electronics manufacturing in 1990 employed 1.94 million workers, vs. 2.03 million in 1989. Those employed in all aspects of electronics, however, including software, communications and other areas of electronic services, would dwarf that figure.
- Electronics R&D expenditures accounted for one of every six dollars expended by *all* industries in the U.S.

Committed to the competitiveness of the American Producer, the Electronic Industries Association (EIA) represents the entire spectrum of companies involved in the manufacture of electronic components, parts, systems and equipment for communications, industrial, government, and consumer-end uses.

Long recognized as a reliable source of accurate statistical information on the electronic industries, the annual *Electronic Market Data Book* contains detailed information on production, sales, foreign trade, R&D, and U.S. Government markets. Covering the many diverse products of the electronic industries, the *1991 Electronic Market Data Book* is based on the data provided to EIA by several hundred companies, supplemented by selected government and private sources.

Some of the data contained in this publication is available free or for a nominal fee from the Federal Government.

A glossary of terms appears at the back of this year's book, for convenient definitions of acronyms and government/electronic related terminology discussed in the text of the publication.

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Introduction

Electronics has been called the most influential technology of the 20th century, and much of its impact is yet to come.

Radio and television, computers, satellites, factory automation, space flight, and sophisticated defense systems are all made possible by electronics. With recent developments in microelectronics technology, allowing hundreds of thousands of electronic circuits to be imprinted on a dime-sized chip of silicon, electronics is now facilitating the everyday functions of banks, supermarkets, kitchens, mail delivery, and offices of every kind. Pick up your phone, start your car, turn on the news, or read a clock and you are in touch with the electronics revolution. During the remainder of this century, electronics will have a pervasive and long-lasting influence on international trade, employment, communications, industrial productivity, entertainment, and our entire way of living.

Electronics is defined as the branch of science and technology that deals with the study, application, and control of the conduction of electricity in a vacuum, gas, liquid, semiconductor, conductor, or superconductor. Electronic products contain material, parts, components, subassemblies, and equipment which employ the principles of electronics in performing their major functions. The ability to influence the flow of electricity distinguishes electronic equipment from that which is merely electrical.

HISTORY

The control of electrons was first achieved in 1883, when Thomas Edison induced electrons to jump across the partial vacuum between a carbon filament and a metal plate in his light bulb. In 1897, the electron was discovered in England by Sir Joseph John Thomson. Electronic communications—the transfer of information from one place to another in the form of electronic circuits—began in 1894 when Oliver Lodge developed a system of wireless communications in England. Around the turn of the century, considerable progress in wireless telegraphy was made by Guglielmo Marconi, Ernest Rutherford, and others. The invention of the three-element vacuum tube by Lee De Forest in 1906 made possible the development of radio broadcasting and the practical application of television.

The usefulness of wireless communications in saving many lives from the Titanic in 1912 and during World War I demonstrated to the United States the importance of being a world leader in developing this technology. Between 1910 and 1920, rapid progress was made in the theory, application, and construction of vacuum tubes and other electric components such as capacitors and resistors. Following the introduction of ground-to-aircraft radio communications during World War I, radio broadcasting stations began operating throughout the United States.

Radio sets were first sold to the public in 1920. The earliest industry statistics show that 100,000 radios were sold in 1922 at an average factory value of $50 each, and in the same year 1 million electron tubes were sold at an average price of $6 each. In 1924, a handful of manufacturers gathered in Chicago to form the Radio Manufacturers Association (RMA), which later became the Electronic Industries Association (EIA). By this time, annual factory sales of radios had jumped to $50 million. An estimated 750 new firms entered the industry between 1923 and 1926, taking advantage of the rapidly expanding market and the fact that relatively little capital or trained labor was needed to manufacture radios.

In 1926, President Coolidge referred to the invention of radio as "one of the most wonderful incidents in the advance of civilization," and told RMA that the Government "stands ready to do what may be done to encourage the development of radio."

In the years to follow, the industry was plagued by such problems as overproduction and patent infringement suits. Consumer preference for well-known brands began to develop, and by 1934, only about 40 U.S. firms remained in the industry. The absence of technical standards presented what was perhaps the industry' greatest problem, and the creation of standardized procedures by the RMA was considered its most significant contribution to the rapid development of radio broadcasting and the eventual introduction of television, FM radio, and other broadcast services.

Although radio manufacturers were hit by the financial failures and low profits of the Depression era, the need for entertainment amidst widespread unemployment made the 1930s the golden years of radio. The years prior to World War II also saw technical progress in many areas, including the development of television, radar, oscilloscopes, voltmeters, and electromechanical analog calculators and computers.

Although television and FM radio were first authorized in 1941, civilian production of electronic products was suspended within a few months after Pearl Harbor, and the radio industry converted its plants and manpower to production of military equipment for communications, detection, surveillance, and guidance. The War Production Board reported that in 1941, factory sales of radios totaled $240 million, and by 1944, the radio and radar industry, including parts manufacturing, reached a peak production rate of $4.5 billion per year—a gain of 1,775%! With the stimulus of multi-million dollar R&D funding, electronics entered a period of extraordinary growth and innovation, leading to the production of sophisticated radar, sonar, testing, measuring, and flight control equipment. Giant calculators, the first form of digital computers, were perfected for use in high-speed data processing, automatic fire, navigation, and flight control.

The cessation of hostilities caused a sharp decline in electronics manufacturing from its wartime peak of 560,000 workers, but the post-war advent of large-scale television production resulted in another upward trend in employment. Also contributing to the post-war growth of consumer electronics was the development of high fidelity sound, FM sound, and the first tape recorders. Sales of radio equipment were superseded by the advent of television, the increasing application of electronics to industrial uses, and expanding military markets.

Wartime research also contributed to a technological breakthrough that transformed the electronic industries: the invention of the transistor, announced by Bell Laboratories in 1947. A transistor consists of semiconducting material—usually silicon—to which minute quantities of impurities have been added, causing it to conduct electricity and perform switching and first used in hearing aids and military products, this tiny, ultra-reliable substitute for the electron tube proved ideal for computers and consumer products. Electronics was soon to become dominated by semiconductor technology.

The laborious, time-consuming process of assembling components into electrical equipment, the growing number of transistors used as switching devices in computer and other digital equipment, and the increasing complexity of circuits eventually led to the next, inevitable breakthrough in electronics: fabricating transistors and other components such as capacitors and resistors from a quarter-inch-square piece of silicon. The integrated circuit (IC) was born in 1959, and produced in mass quantities by 1962.

The growth of the semiconductor industry was made possible by large orders from the U.S. Department of Defense for integrated circuits used in military equipment in the late 1960s. This led to huge increases in production, resulting in rapid price decreases which made semiconductors cost-effective for many consumer, industrial, and commercial applications. This also helped to stimulate growth of digital computer technology and markets.

It soon became feasible to combine thousands of circuits into a single silicon chip, in a technique known as large-scale integration (LSI). During the past two decades, phenomenal increases in the number of circuits that can be imprinted on a chip have been accompanied by huge reductions in cost and energy consumption. By the end of the 1970s, the United States was selling over $6 billion worth of semiconductors annually to world-wide markets, and the advanced industrial nations were racing to develop "very large-scale integration" (VLSI), in which hundreds of thousands of circuits are etched onto a chip using lithography of micrometer line widths.

Since most of the time and expense needed to produce ICs comes at the design stage, the use of special chips for particular applications has often been discouraged by the complexity of the design required. This has fostered the development of the microprocessor, in which the entire central processing unit of a computer—the complex circuitry that processes information and carries out computations—is contained on a silicon chip. Because its software can be altered to fit a variety of applications, the microprocessor can be incorporated relatively cheaply into a wide range of products and systems from cruise missiles to children's toys.

The growth of electronics has thus been built on the development of circuits, from the vacuum tube to the transistor to the integrated circuits. While the phenomenal potential of semiconductor technology has only begun to be realized, ongoing research in VLSI, optical circuitry, superconduction, and other technologies may soon lead to yet another era in electronics technology.

Summary

THE ECONOMIC CLIMATE

The U.S. economy grew at a real rate of 1.0% in 1990. A number of factors contributed to the poor performance, including: the Gulf War, uncertainty about the pace of inflation, and the level of interest rates. While the 2.8% real increase in government purchases of goods and services in 1990 was a stimulus for the economy, it came at the expense of a federal budget deficit in excess of $200 billion. The economy is not expected to fare much better in 1991, according to the *Blue Chip* Economic Consensus. The consensus forecast for real growth in all of 1991, is just 0.1%, with negative real growth expected in at least the first quarter of 1991.

Spending in the consumer sector, as measured by real personal consumption expenditures (PCE), paralleled growth in the economy as a whole, with real growth of 1.0% for 1990. PCE are forecast to decline at a rate of 0.2% in 1991, according to the *Blue Chip* Economic Consensus. The CPI for all items rose at an average annual rate of 5.4% in 1990 and is forecast to rise 4.8% in 1991. Consumer confidence, which was already flagging in the months leading up to the Iraqi invasion of Kuwait, took a nosedive in the last quarter of 1990. Consumer reluctance took its toll on almost all major sectors of consumer durables dealers and manufacturers. The total consumer electronics market in the U.S. did manage nominal growth of 4.0% in 1990. This is a solid performance in an industry where prices for goods tend to resist overall inflationary tendencies and quality is continually increasing.

Performance in the industrial sector of the economy was also weak in 1990. Industrial production rose at an average annual rate of 0.8% in 1990, while productivity in the U.S. economy fell 0.8%. Real nonresidential fixed investment grew at nearly twice the rate of GNP in 1990, rising 1.8% The Producer Price Index rose 4.9% in 1990, outpacing nominal unit labor costs, which grew 4.3% in 1990. The outlook for industry in 1991 is much the same as for the overall U.S. economy: negative real growth in the first half of 1991 followed by a very slight rebound in the second half of 1991. The outlook for 1991 is dependent on a continuing fall in interest rates, slowing inflation, and the continued strong performance of U.S. exports.

ELECTRONIC INDUSTRIES OVERVIEW

Given the overall economic climate in which the electronic industries will operate, more growth for these industries likely will come from higher participation rates *within* broad economic segments, rather than through growth of the segments themselves.

Selected U.S. Economic Data, 1981-1991 **TABLE I**

Dollars & Indices	REAL GNP[1]	REAL PCE[2]	CPI ALL ITEMS[3]	INDUSTRIAL PRODUCTION[4]	GOVERNMENT PURCHASES[5]
1981	3248.8	2024.2	90.9	85.7	629.7
1982	3166.0	2050.7	96.5	81.9	641.7
1983	3279.1	2146.0	99.6	84.9	649.0
1984	3501.4	2249.3	103.9	92.8	677.7
1985	3618.7	2354.8	107.6	94.4	731.2
1986	3717.9	2446.4	109.6	95.3	761.6
1987	3853.7	2513.7	113.6	100.0	781.8
1988	4024.4	2598.4	118.3	105.4	785.1
1989	4117.7	2656.8	124.0	108.1	798.2
1990p	4156.3	2682.5	130.7	109.0	820.5
1991e	4159.1	2677.1	137.0	107.8	837.3

NOTES:

1. Gross National Product in billions of 1982 dollars.
2. Personal Consumption Expenditures in billions of 1982 dollars.
3. Consumer Price Index, Total, All items, 1982-1984 = 100
4. Index of total Industrial Production, 1987 = 100
5. Total federal, state and local government purchases of goods and services in billions of 1982 dollars

U.S. Factory Sales of Electronics by Industry Group ($ Million); 1981-1990

TABLE II

YEAR	COMPUTERS AND INDUSTRIAL ELECTRONICS[1]	COMMUNICATIONS EQUIPMENT[2]	ELECTRONIC COMPONENTS	CONSUMER ELECTRONIC PRODUCTS[3]	OTHER RELATED PRODUCTS/ SERVICES[4]	TOTAL[5]
1981	47,655	35,659	28,784	12,438	na	118,172[r]
1982	53,320	39,130	29,561	14,309	na	128,380[r]
1983	57,265	42,119	33,856	17,625	na	139,135[r]
1984	69,474	49,529	43,306	21,374	35,652[r]	204,770[r]
1985	70,310	57,095	39,459	25,301[r]	39,839[r]	212,813[r]
1986	69,942[r]	59,823	38,829	27,538[r]	42,600[r]	217,465[r]
1987	76,048[r]	62,368	45,335	29,023[r]	44,433[r]	234,251[r]
1988[r]	78,748	63,705	50,988	30,247	48,255	248,922
1989[r]	80,616	63,606	54,937	31,666	48,727	254,099
1990[e]	83,350	66,575	55,164	32,937	54,495	265,966

[1] Includes sales of home computers.
[2] Includes sales of home telephones and answering devices.
[3] Includes sales of home computers, home telephones and answering devices, and consumer electronics imports (see Table 1-1).
[4] Includes EIA estimate of the electronic content of the annual sales of industries considered to be partially electronic.
[5] Totals do not add due to overlapping product scopes of industry groups and exclusion of consumer electronics imports from totals.
[r] Revised.
[e] Estimated.
[na] Not Available (Not included in Grand Total).

The decade of the '90s likely will witness more interaction among and between the various sectors of the electronics industry, as well as a higher degree of involvement in other industries. For example, the grey area between "industrial" and "consumer" electronics has grown larger as more consumers have added personal computers, copiers, facsimile machines, and other electronic products to their home offices. Moreover, the electronic "content" in virtually every facet of society continues to grow.

Like the U.S. economy, the electronic industry is so huge that its *total* growth cannot be expected to exhibit large percentage changes from one year to the next. U.S. factory sales of all electronic equipment totalled $266 billion in 1990, up nearly 5% over 1989. An estimated $58 billion of this total is accounted for by sales to the defense electronics market. Except for the top 13 or 14 *countries* in the free world, this figure is larger than all other GROSS NATIONAL PRODUCTS! The electronics industries total also exceeds the sizes of such basic U.S. industries as automobiles, steel and chemicals.

The total electronics figures in Table II have been calculated to reflect only domestic factory shipments. The figures for consumer electronics, however, include imports, to better reflect total U.S. market activity. In 1990 it is estimated that domestic factory sales of consumer electronics increased about 3% to $6.4 billion.

Table II also contains a category called "other related products and services." Figures within this category reflect the estimated value of the electronic content of other industries such as motor vehicles and aircraft, where electronics are finding an increasing number of applications. These figures also reflect a portion of the value of related service industries, the principal one being computer software.

1 Consumer Electronics

The consumer electronics industry swept into the decade of the 80's on a technological tidal wave that brought with it a new generation of entertainment, educational and commercial products and systems—many made possible by the tiny microprocessor chip. The tidal wave has continued into the '90s as more products and systems continue to be introduced that impact Americans' lives and lifestyles. Products such as interactive television, CDTV, digital compact cassette recorders, and others, continue to change and fine tune the home entertainment, communication and educational possibilities available in the United States and around the world.

Representing an estimated $44 billion in retail value last year, the major consumer electronic product categories include: **Video**—television, videocassette recorders, laserdisc players, camcorders and satellite earth stations; **Audio**—compact disc players, components, compacts and personal units, tape equipment, radios, and car audio; **Home Information Equipment**—home computers, electronic typewriters, personal copiers, facsimile machines, calculators, accessories, software, telephones, telephone answering devices and hand-held reference products; **Home Automation Products**, including universal remote controls; **Assistive Devices**—hard-

Factory Sales of Consumer Electronic Products (Including Imports) ($ Million); United States, 1981-1990 **TABLE 1-1**

CATEGORY	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Monochrome TV Receivers, incl. LCD	505	507	465	419	328	373	341	236	156	132
Color TV Receivers, incl. LCD	4,349	4,253	5,002	5,538	5,565	6,040	6,303	6,277	6,530	6,376
Projection TV	287	236	268	385	488	529	527	529	478	626
VCR Decks	1,127	1,303	2,162	3,585	4,738^r	3,978	3,442	2,848	2,625	2,439
Camcoders[1]	—	—	—	—	—	1,280	1,651	1,972	2,007	2,260
Color Cameras	147	232	303	355	228	59	na	na	na	na
Laserdisc Players	55	54	81	45	23	26	26^r	34^r	50^r	72
Audio Systems	720	573	630	976	1,372	1,370	1,048	1,225	1,217	1,270
Separate Audio Components	1,363	1,181	1,268	913	1,132	1,358	1,715	1,854	1,871	1,935
Home Radios	501	530	565	661	379	408	409	377	379	360
Portable Audio Equipment[2]	1,157	971	1,102	1,191	1,140	1,389	1,469	1,547	1,595	1,645
Car Audio	2,000	2,100	1,900	2,500	2,761	3,135	3,523	3,937	4,125	4,292
Blank Audio Cassettes	227	202	234	256	270^r	300^r	375^r	367^r	384^r	376
Blank Videocassettes	—	357	580	770	1,055	1,235	1,006	936	923	948
Accessories[3]	—	—	—	—	—	—	748	847	829	852
Total	12,438	12,499	14,560	17,594	19,479^r	21,480^r	22,583^r	22,986^r	23,169^r	23,583
Estimates by Consensus[4]	na	1,810	3,065	3,780	5,822	6,058^r	6,440^r	7,261^r	8,497^r	9,354
GRAND TOTAL[5]	12,438	14,309	17,625	21,374	25,301^r	27,538^r	29,023^r	30,247^r	31,666^r	32,937

[1] Prior to 1986, data included in VCR Decks.

[2] Prior to 1987, data exclude CD players.

[3] Prior to 1987, data included in Estimates by Consensus.

[4] Includes videocasette players, home satellite earth stations, home computers, telephone equipment, facsimile devices, electronic typewriters and home security systems. Prior to 1985, data reflect home computers and telephone equipment only.

[5] Grand total reflects exclusion of home computer software sales, which are not considered totally electronic.

r-Revised.

SOURCE: EIA Marketing Services Department.

Factory Production[1] of Television Receivers (Thousands); United States, 1981-1990

TABLE 1-2

	MONOCHROME		COLOR		TOTAL MONOCHROME AND COLOR	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981	6,056	539,000	12,423	4,683,000	18,479	5,222,000
1982	4,922	437,000	11,484	4,288,000	16,406	4,725,000
1983	5,647	459,000	14,034	5,047,000	19,681	5,506,000
1984	5,194	431,000	17,190	5,896,000	22,384	6,327,000
1985	3,620	304,000	16,905	5,629,000	20,525	5,933,000
1986	3,975	330,000	19,010	6,268,000	22,985	6,598,000
1987	3,650	296,000	19,847	6,470,000	23,497	6,766,000
1988	2,365	149,000	20,147	5,923,000	22,512	6,072,000
1989	1,720[r]	120,000[r]	23,139	6,919,000	24,859[r]	7,039,000[r]
1990	1,425	100,000	20,840	6,335,000	22,265	6,435,000

[1] Includes domestic production and imports.

[r] Revised.

SOURCE: EIA Marketing Services Department.

ware and software that assists individuals with disabilities, including electronic health care products; and **Personal Electronics**—watches, electronics games and toys, appliances and musical instruments.

In the area of video, current emphasis centers on the slow but steady emergence of advanced television and new uses for the television screen. Digital hi-fi and multi-channel sound for video are sparking a renewed surge of interest in audio and leading to the integration of audio and video into products such as the new combi-players, which play both compact audio discs and video discs.

The complex combinations of audio and video are perhaps best demonstrated by the increasingly popular home theater concept. The combination of multi-dimensional surround sound and theater-quality video creates truly amazing home entertainment unlike any previously possible.

In the area of audio, digital audio is setting higher standards for sound quality and reproduction than ever before. The trend continues towards multi-room systems and secondary systems in rooms other than the main home entertainment listening or viewing room.

Personal computers, video games, facsimile machines and personal handheld reference devices have also drastically altered the way millions of Americans spend their working and leisure hours. 1990 was the introduction of multi-use products which combine business and entertainment functions, such as handheld video game products which also serve as electronic spellcheckers and language translators.

Home automation moved ahead in 1991 with the opening of the world's first public working display of a fully-automated house. As new products are introduced, the "electronic home of tomorrow" is quickly becoming a reality.

Accessory items and new types of software continue to enhance the enjoyment and utility potential of all our industry's product categories for millions of users. And, assistive devices of all kinds are enabling people with functional limitations to live more fully and productively than ever before.

Unit sales to retailers of such items as camcorders, compact disc players, cellular telephones and telephone answering devices set new all-time records in 1990, resulting in an overall value of factory sales of approximately $32.9 billion, with an estimated value of over $44 billion at retail. According to a consensus of manufacturers, a 3.3 percent growth rate is expected for 1991, bringing total factory sales to just under $34 billion.

Color television receivers continued as the industry's largest dollar value product, with factory sales of more than $6.3 billion, followed by car audio with sales of nearly $4.3 billion.

All categories of video account for about 38% of the consumer electronics total, while audio represents 30%, and all other "CE" products account for 32%. The fast-growing home information equipment segment constitutes a large part of the "other" category.

CONSUMER ELECTRONICS— ITS ORIGIN AND HISTORY

The consumer electronics industry is now well into its second half-century and has entered a period of unparalleled innovation. It took shape as an industry in 1920, with the start of radio broadcasting in the United States, when the first radio receiving sets were offered to the public. It was then known as the radio industry, and the word "electronics" was not to come into common use for 25 years. But "cat's whisker," "crystal set," "earphones" and "B-battery" became bywords with those who were captivated by this miraculous advance in home entertainment.

By 1922, radio was more than a fad, and the earliest statistics by what is now EIA show that 100,000 were sold that year at a factory value of $5 million—an average of $50 each. When EIA's predecessor association was organized two years later (as the Radio Manufacturers Association), radio's annual factory volume had multiplied tenfold to $50 million.

Origins in 1877

Contributing to the birth of consumer electronics were many earlier landmarks. Perhaps the most significant were Edison's 1877 invention of the phonograph, Fleming's development of the electron tube in the 1890s, Marconi's first wireless transmission in 1895 and DeForest's 1906 inventions which led to the electronic amplifier.

Perhaps radio wouldn't have been an instant success had not Americans been conditioned to living-room sound entertainment by the phonograph, which was already more than 40 years old when it was joined by the radio in the front parlor. At first a purely mechanical-acoustical device, the phonograph later entered the consumer electronics family by marriage to the radio—its sound box replaced by electronic amplification, its spring drive by an electric motor.

The period from 1920 until America's entry into World War II in 1941 was the age of radio, in which 100 million receivers were sold (less than the number sold in 1972 and 1973 alone). During this time came such dynamic innovations as the loudspeaker, the superheterodyne circuit, the line-cord radio, the automobile radio and the portable set which operated both from AC and battery.

Mobilization and War

Although television and FM radio were initially authorized in 1941, their popularization was to wait until after World War II. All civilian production was suspended during the war, when the radio industry turned its attention to electronic devices for communication, detection, surveillance and guidance.

Under the pressure of wartime requirement, the old "radio industry" grew in both sophistication and size. On resumption of civilian production late in 1945, it was ready to satisfy a huge pent-up demand for radios and phonographs and to launch a wave of new products which still shows no signs of abating.

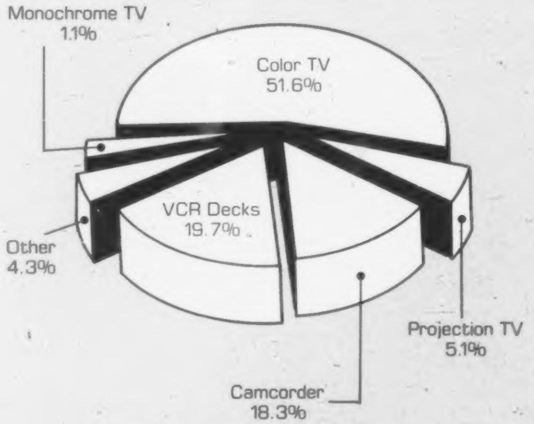
VIDEO EQUIPMENT

The Transformation—From TV to Video

A transformation which is both evolutionary and revolutionary is now underway—changing not only the nature of the consumer electronics industry but the American home and the American lifestyle. The key word is "video"—and the changes involve our basic sources of information, entertainment, education and communication. The video revolution with its potential effects already has been compared to the revolution of the early 20th Century brought about by the automobile.

For many years, the conventional television set served one purpose—the reception and reproduction of broadcast programs. Community Antenna TV (CATV) systems, which augmented the choice of broadcasts and improved reception, evolved into today's cable TV, which now may provide up to 100 channels or more of entertainment, information and service. To basic cable was added premium service or pay television. Similar services—including broadcast subscription TV and microwave-delivered pay TV—were added in areas where cable had yet to penetrate. Other new program sources began to proliferate. Suddenly the television screen became an all-purpose display device, a visual nerve center of the home, as programming evolved from an economy of scarity to one of abundance. Video games let viewers interact with their screens for the first time.

Distribution of Factory Sales of Video Equipment by Type (%); United States, 1990 **FIGURE 1-A**



Total = $12,360 Million

SOURCE: Table 1-1.

Videocassette recorders (VCRs) allow users to rearrange time and create their own program viewing schedule. Along with VCRs, videodisc players provide access to broad new choices of programs to augment "real time" broadcast and cable transmissions. Camcorders have replaced film cameras for home movie making, and are creating a generation of "do-it-yourself" program producers.

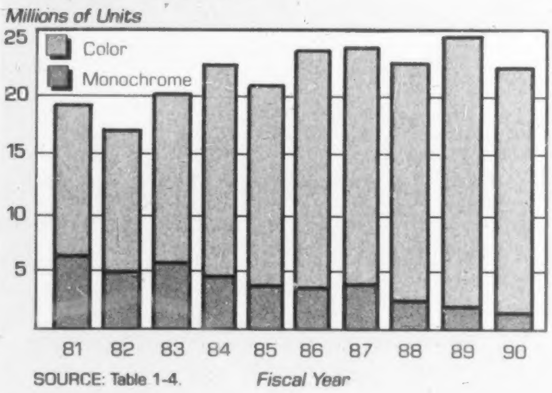
Color Television

These many new uses and requirements are important contributors to the continuing—and accelerating—demand for color television receivers, year after year, in good times and bad. Color TV, the basic receiver and visual display for the world of video, is the "flagship" product of the consumer electronics industry, representing more than 20% of the total factory dollar volume of consumer electronics products.

Manufacturers and distributors have sold more than 20 million color TVs annually in each of the last three years. That is a remarkable record considering 96% of all American TV homes already own at least one color set, and more than half have two or more. A steady demand from buyers seeking to replace or upgrade existing color TVs and from those seeking an extra set for the bedroom, den or kitchen, helps keep sales at such a high level. It is estimated that replacement and second (or third) set purchases account for more than 60% of all color TV sales.

Big-screen, direct-view color TVs with 27-inch, 30-inch, 31-inch and even 35-inch tubes, was a growth area in 1990, a year in which overall color TV sales declined slightly in a continuing trend, and table models 25-inches and over outsold consoles. The 20-inch table model was the industry's best seller in 1990, leaving the former market leader, the 19-inch table model, in second place for the second consecutive year. Market demand also continued strong for 13-inch, 14-inch and 25-inch table models. In 1991, manufacturers will be offering a wider variety of models of big-screen color TVs and will be putting even more emphasis on models with improved resolution for sharper, more detailed pictures.

Annual Factory Production of Television Receivers by Type (Millions of Units); United States, 1981-1990 **FIGURE 1-B**



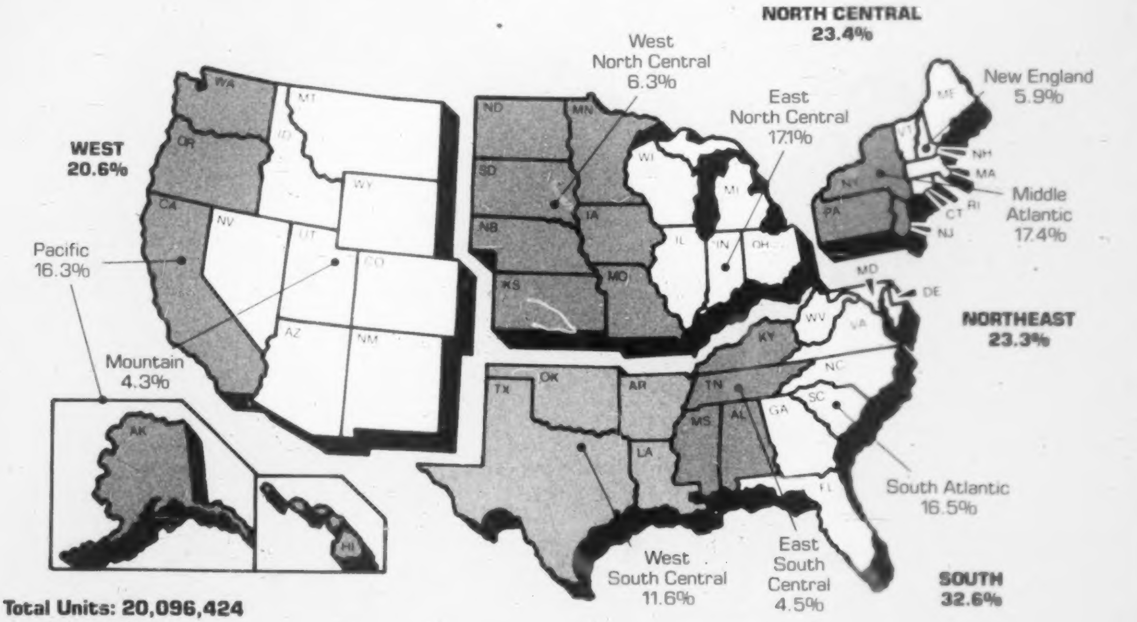
SOURCE: Table 1-4.

Remote control, once a relatively expensive step-up feature, is now a virtual standard on all big tube table and console color TV models. It is included on the majority of 19-inch and 20-inch sets manufactured today, and is available on smaller screen TVs. Along with the growth of remote control has been an increase in the number of new color TVs using quartz-synthesized computer tuning, making possible random-access selection of a wide variety of channels.

With more than 50% of all TV homes now hooked into cable TV systems, manufacturers offer color sets which are cable-compatible. These sets can tune in a varying number of nonscrambled cable channels without the use of external converters. This tuning feature makes it possible to use the TV set's remote control features with cable TV. It can also save money for those served by cable systems which offer a reduced monthly rate to subscribers who don't require a converter box. The majority of sets sold last year were so equipped.

The trend to personal portable consumer electronics has extended to color television. Pocketable receivers with 2-inch and 3-inch liquid crystal displays (LCD) are generally available in the market. Advances in LCD know-how have made it possible to offer such pocket TVs that provide resolution and color fidelity that approaches that available from conventional

Estimated Total Sales to Dealers of Color Television Receivers by Region (%); United States, 1990[1] **FIGURE 1-C**


NORTH CENTRAL
23.4%
West
North Central
6.3%
East
North Central
17.1%
New England
5.9%
WEST
20.6%
Middle
Atlantic
17.4%
Pacific
16.3%
NORTHEAST
23.3%
Mountain
4.3%
South Atlantic
16.5%
West
South Central
11.6%
East
South
Central
4.5%
SOUTH
32.6%
WA
OR
CA
MT
ID
WY
NV
UT
CO
AZ
NM
ND
SD
NB
KS
MN
IA
MO
WI
MI
IL
IN
OH
ME
VT
NH
MA
NY
PA
CT
RI
NJ
MD
DE
WV
VA
KY
NC
TN
SC
GA
AL
MS
TX
OK
AR
LA
FL
AK
HI

Total Units: 20,096,424

[1] Excludes institutional.

picture tubes. Prototype portable and desk top LCD color TVs in larger sizes ranging from 7-inches to 14-inches have been shown, and some could enter the market in 1991. Many in the industry feel that advances in LCD and other display technologies will eventually lead to the introduction of large, flat, wall-hung color TV displays.

Advanced Television

With the application of digital signal processing technology to the home receiver, the age of advanced TV has begun. The first step, IDTV (Improved Definition TV), has already been taken, and IDTV receivers are on the market. Such receivers use integrated circuit memories to store incoming standard National Television System (NTSC) video images, then employ computer technology to study the pictures line-by-line. Additional lines of picture information are generated and inserted and the result is a derived 1,050-line TV display that offers the appearance of twice the sharpness of the original.

Phase two, which may or may not make an appearance in the U.S., is EDTV (Extended Definition TV) or ACTV (Advanced Color TV). In such systems picture enhancement information is added at the program source (broadcast, cable, tape, disc, etc.) and decoded and utilized by the receiver to provide double-resolution displays, and in some instances, wide-screen images with a 16:9 aspect ratio similar to that used by movies. Conventional TVs have a 4:3 aspect ratio, which means that for every four inches in picture width there are three inches in height. EDTV and ACTV signals are designed to be compatible with existing transmission standards. This means no changes are needed in the present broadcasting system, and that the incoming signals can be viewed, but without the enhancements, on conventional TV receivers.

Annual Factory Production[1] of Color Television Receivers by Type (Thousands of Units and % of Total); United States, 1981-1990

TABLE 1-3

YEAR	TABLE AND PORTABLE	TABLE AND PORTABLE % OF TOTAL	CONSOLE	CONSOLE % OF TOTAL	TV/VCR COMBINATIONS	COMBINATIONS % OF TOTAL	TOTAL
1981	9,851	79.3	2,572	20.7			12,423
1982	9,102	79.3	2,382	20.7			11,484
1983	11,221	80.0	2,813	20.0			14,034
1984	13,977	81.3	3,213	18.7			17,190
1985	14,087	83.3	2,818	16.7			16,905
1986	15,964	84.0	3,046	16.0			19,010
1987	17,292	87.1	2,555	12.9			19,847
1988	17,826	88.5	2,321	11.5			20,147
1989	20,863	90.2	2,276	9.8			23,139
1990	18,525	88.9	1,829	8.8	486	2.3	20,840

[1] Includes domestic production and imports.
[2] Not separately available, but included in total.

Factory Sales[1] of Television Receivers (Thousands of Units and Dollars), United States, 1981-1990

TABLE 1-4

YEAR	MONOCHROME		COLOR		TOTAL MONOCHROME AND COLOR	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981	5,654	504,620	11,769	4,349,490	17,423	4,854,110
1982	5,692	506,881	11,673	4,252,951	17,365	4,759,832
1983	5,735	464,535	14,310	5,001,996	20,045	5,466,531
1984	5,050	419,150	16,563	5,537,659	21,613	5,956,809
1985	3,684	309,456	17,145	5,562,398	20,829	5,871,854
1986	3,953	328,099	18,768	6,024,624	22,721	6,352,723
1987	3,547	287,307	19,753	6,271,419	23,300	6,558,726
1988	2,574	162,162	20,886	6,090,812	23,460	6,252,974
1989	1,656	115,920	23,013	6,783,842	24,669	6,899,762
1990	1,411	98,770	21,654	6,525,688	23,065	6,624,458

[1] Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Color Television Receivers by Type (Thousands of Units and Dollars); United States, 1981-1990

TABLE 1-5

	TABLE AND PORTABLE		CONSOLE		TV/VCR COMBINATIONS		TOTAL	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981	9,308	3,025,472	2,461	1,324,018			11,769	4,349,490
1982	9,207	2,958,301	2,466	1,294,650			11,673	4,252,951
1983	11,424	3,518,592	2,886	1,483,404			14,310	5,001,996
1984	13,453	3,995,335	3,110	1,542,324			16,563	5,537,659
1985	14,163	4,163,780	2,982	1,398,618			17,145	5,562,398
1986	15,835	4,607,985	2,933	1,416,639			18,768	6,024,624
1987	17,225	5,012,475	2,528	1,258,944			19,753	6,271,419
1988	18,410	4,860,240	2,476	1,230,572			20,886	6,090,812
1989	20,839	5,709,886	2,174	1,073,956			23,013	6,783,842
1990	19,235	5,366,565	1,994	981,048	425	178,075	21,654	6,525,688

[1] Includes factory sales to distributors and factory direct sales to dealers and factory export sales.

[2] Not separately available, but included in total.

SOURCE: EIA Marketing Services Department.

The final stage is HDTV (High Definition TV) which, when it arrives, will bring with it true double-resolution TV displays nearly equal in quality to that of 35mm film, plus top quality digital stereo sound. Most true HDTV systems under consideration for use in the U.S. require the use of a signal that occupies space equivalent to one and one-half to two full standard TV channels. While that represents no technical hurdle for cable, satellite, tape or disc delivery, changes in present broadcast standards would be needed for over-the-air transmission.

The FCC, which has begun consideration of the best way to bring HDTV to the market, has already set some ground rules for the future, the most critical being that any HDTV system used for broadcasting must be compatible with the present system. While this does leave the door open for cable operators or VCR manufacturers, for example, to utilize a nonbroadcast standard, that is generally not expected to happen. Considering the estimated high cost of big-tube wide-screen TVs, consumers are not likely to accept the idea of having a different HDTV receiver for each source. Nor do manufacturers appear interested in producing unnecessarily expensive multi-standard HDTV sets. Therefore, the broadcasting standard is expected to become the standard for all HDTV delivery systems.

There are a number of different HDTV standards proposals under study by industry and government groups, including one that calls for a two-stage approach. It would start with an ACTV system that would provide wide-screen pictures of a quality somewhat less than true HDTV, plus digital stereo audio sound and ghost elimination. Successful over-the-air test of ACTV broadcasts have already been conducted. The second stage, HDTV, would follow some years later, after all technological and broadcast spectrum allocation issues have been resolved.

Sales to Dealers[1] of Television Receivers (Thousands of Units), United States, 1981-1990

TABLE 1-6

YEAR	MONOCHROME	COLOR	TOTAL MONOCHROME AND COLOR
1981	5,541	11,157	16,698
1982	5,765	11,366	17,131
1983	5,697	13,986	19,683
1984	4,909	16,083	20,992
1985	3,754	16,995	20,749
1986	3,959	18,204	22,163
1987	3,570	19,330	22,900
1988	2,580	20,216	22,796
1989	1,656	21,706	23,362
1990	1,411	20,808	22,219

[1] Includes distributor sales and factory direct sales to dealers.

SOURCE: EIA Marketing Services Department.

Sales to Dealers[1] of Color Television Receivers by Type (Thousands of Units and % of Total); United States, 1981-1990

TABLE 1-7

YEAR	TABLE AND PORTABLE	TABLE AND PORTABLE % OF TOTAL	CONSOLE	CONSOLE % OF TOTAL	TV/VCR COMBINATIONS	COMBINATIONS % OF TOTAL	TOTAL
1981	8,805	78.9	2,352	21.1			11,157
1982	8,904	78.7	2,426	21.3			11,366
1983	11,179	79.9	2,807	20.1			13,986
1984	13,092	81.4	2,991	18.6			16,083
1985	13,993	82.3	3,002	17.7			16,995
1986	15,399	84.6	2,805	15.4			18,204
1987	16,805	86.9	2,525	13.1			19,330
1988	17,768	87.9	2,448	12.1			20,216
1989	19,557	90.1	2,149	9.9			21,706
1990	18,453	88.7	1,931	9.3	424	2.0	20,808

[1] Includes distributor sales and factory direct sales to dealers.
[2] Not separately available, but included in total.
SOURCE: EIA Marketing Services Department.

The FCC's decision on a suitable U.S. standard for HDTV broadcasting will be based on a recommendation by its Advanced TV Committee, which is scheduled to start field testing the various systems now under consideration in 1991. Those tests will run on into 1992. After the tests have been completed and the results analyzed, the FCC will select a standard. At about that same time, the FCC is expected to consider the advisability of authorizing the use of an interim advanced TV system.

The selection of an HDTV system is not something to be taken lightly. The current TV broadcasting system, altered only slightly to accommodate color, has delivered quality pictures and audio to American consumers for more than 50 years. Over time, the transition to HDTV will require the investment of tens of billions of dollars in new TV production and broadcasting equipment and home receivers and recorders. The development of a totally new HDTV system that will have to serve American consumers well into the next century is something that cannot be rushed.

The fact that the science of video refuses to stand still has further slowed the process. Three of the four systems slated to be tested did not exist at the start of last year, when the testing schedule was first penciled in. Those three use new all-digital signal compression technologies that hold the promise of providing image and audio quality unmatched by the HDTV systems planned for use in Europe and Japan.

The current schedule calls for the FCC to make its standards selection in late 1993, and the first receivers would start appearing in stores about a year later. But that assumes the tests go as expected, and that some totally new and even better concept does not suddenly crop up and have to be factored into the standards equation. The first HDTV sets are likely to cost several times as much as their counterparts of today, and it will take several years for the majority of broadcasters to re-equip. It will probably require most of the rest of this decade for HDTV to become the nation's most popular way of watching TV, in much the same way that it took 10 years before color TV sets were in 50% of American homes.

The Sound of Stereo Comes to TV

The metamorphosis from television to video is also seeing a new emphasis on a sometimes neglected link in the TV chain—audio. While the move to improve sound quality started several years ago, it was given a strong boost in 1984 when the Federal Communications Commission approved the start of true stereo audio broadcasts by TV stations. Though the FCC did not specify a standard, TV set manufacturers and broadcasters adopted the system recommended by the EIA Multichannel TV Sound Subcommittee.

All commercial TV networks, the Public Broadcasting System, most local TV stations and satellite transmissions now feature stereo audio on regularly scheduled and special broadcasts. Virtually all American TV homes are within reach of a TV signal with stereo audio. Also, nearly all cable TV systems are supplying stereo to their subscribers.

While overall sales of direct-view color TVs were off slightly last year, sales of stereo sets enjoyed a sixth straight year of double-digit increases. The stereo feature was included in a record 32% of all color TVs sold in 1990, exceeding industry expectations, and it is anticipated that the stereo penetration level will rise again this year. Stereo is now virtually a standard feature in projection TVs and is found in a steadily growing percentage of home VCR decks. The number of broadcast and cable TV programs being transmitted with stereo audio are also steadily rising.

The EIA system provides far more than just binaural audio. An important aspect is a third, alternative, sound channel called Separate Audio Program (SAP). While broadcasters can use the SAP for any purpose, in areas with large ethnic populations stations are using it for bilingual broadcasts which help bring millions of non-English speaking citizens into the mainstream of American television. Alternatively, SAP could allow for separate novice and professional commentaries during televised sports events, or to give the viewer of a foreign film a choice between the original or English dubbed soundtrack.

Factory Sales[1] of Integral MTS Color Television Receivers (Units and % of Total); United States, 1987-1990

TABLE 1-8

YEAR	INTEGRAL MTS UNITS	INTEGRAL MTS % OF TOTAL COLOR TV FACTORY SALES
1987	4,349,078	22.5
1988	5,090,425	25.2
1989	6,043,397	27.8
1990	6,655,193	32.0

[1] Includes factory sales to distributors and factory sales to dealers and factory export sales.

SOURCE: EIA Marketing Services Department.

Many of the new stereo TV receivers come with stereo audio amplifiers and speakers. Most have audio output jacks to permit the sound to be fed to a separate hi-fi system. All models will receive both the two-channel stereo and the SAP audio signals. Also available are SAP-only models that offer the viewer a choice between the regular (monaural) audio or the SAP audio signal.

There are add-on options too, for consumers who want to enjoy TV stereo audio but are not yet ready to purchase a new color TV. Also available are complete TV stereo audio tuners. Some receive TV audio only, others also tune FM and AM radio. Some of them come complete with a stereo audio amplifier and speakers; others are intended for use with separate audio systems.

Stereo audio for TV is not a new concept. Millions of viewers have enjoyed stereo audio from videocassettes, videodiscs and "simulcast" programs for which the stereo audio portion can be taken from a cable or picked up by an FM radio.

Monochrome TV

Despite the popularity of color TV, there is still a sizable demand for black-and-white models. Last year, more than 1.4 million conventional tube type, and more than 500,000 pocketable sets with liquid crystal displays were sold to retailers. Virtually all monochrome sets sold today are portables or table models. In table models, the dominating screen size is 12-inch, and many are designed for either AC or 12-volt operations, so they can be used on boats, trailers and recreational vehicles. Smallscreen battery portables, including models with flat tube and liquid crystal displays, account for more than 50% of industry sales volume. Helping bolster the popularity of B&W TVs are small screen combos that include a radio and/or audio cassette recorder. Many home night tables and office desks now hold a compact b&w TV/FM-AM clock radio combination.

Projection TV

Giant-screen projection color TV is an important part of the video industry product spectrum, and virtually every major TV manufacturer features at least one model. In 1990, unit sales of projection sets hit an all-time high, an impressive achievement considering the record was set in the face of the growing consumer demand for giant-tube direct-view color models.

While pricing has come down over the years, projection TVs are still quite expensive, a reflection of the high cost of the precision optics and special electronic display systems utilized.

New configurations and styles of projection television are making these systems more acceptable in a great number of American homes. There are currently three major types of projection TV, with screen sizes from about 35 inches to more than 10 feet in diagonal measurement. Two-piece units employ separate screens and projector-receivers. One-piece front projection systems have foldout or hinged drawers containing the picture source, keeping the cabinet relatively compact when the TV is not in use. Single-piece rear-projection units have translucent screens which display the picture projected from the inside of the cabinet.

While improvements in conventional three-tube front and rear projection TVs continue to be made, a new system of giant-screen displays is now on the market. Long in development, and now a reality, are color video projectors that use liquid crystal displays as light valves. The new generation of projectors take up no more table top space than a 19-inch TV and can be picked up and stored in a cabinet when not in use. LCD projectors use high brightness bulbs as a light source and are adjustable to throw a 3-foot to 10-foot display on an ordinary movie screen or even a white wall. Technical limitations on the number of individual picture elements, or pixels, limit the image resolution, but advances in that area are being made rapidly. Current LCD projectors are premium priced, and so appeal mainly to business users and the most upscale of consumers. Over the next several years, however, increased volume and lower costs should see LCD projection TVs become price competitive with conventional models.

Production and Sales of Projection Televisions (Units); United States, 1981-1990

TABLE 1-9

YEAR	FACTORY PRODUCTION[1]	FACTORY SALES[2]	SALES TO DEALERS[3]
1981	179,172	139,322	121,650
1982	126,705	118,110	117,253
1983	114,314	140,807	143,506
1984	217,142	204,463	195,194
1985	278,971	269,436	265,645
1986	342,167	307,794	304,272
1987	314,358	299,902	293,084
1988	276,596	299,995	301,784
1989	288,766	274,242	265,300
1990	281,574	358,638	351,402

[1] Includes domestic production and imports.

[2] Includes factory sales to distributors and factory direct sales to dealers and factory export sales.

[3] Includes distributor sales and factory direct sales to dealers.

SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Projection Televisions (Thousands of Units and Dollars); United States, 1981-1990

TABLE 1-10

YEAR	UNITS	DOLLARS
1981	139	286,534
1982	118	235,748
1983	141	267,686
1984	204	385,356
1985	269	487,697
1986	308	529,760
1987	300	526,500
1988	300	523,800
1989	274	494,022
1990	359	640,456

[1] Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

Home Theater

The arrival of high quality, bigger-screen direct-view and projection color TVs plus stereo audio, has launched a new video market phenomena, the home theater experience. The impact of the enhanced sight and sound available from video equipment today can approximate the entertainment atmosphere that until now could only be found in the most modern movie theaters. Recreating at least the basics of a theater at home requires only a larger-tube TV equipped with hi-fi quality stereo sound capability. But after that, the sky is the limit.

A next step up would be to a stereo direct-view or projection TV with a built-in surround-sound decoder with extra speakers for the rear audio channels. Alternatives to broadcast or cable programming are provided by adding a videocassette recorder, videodisc player or video game.

The complete home theater system would include the TV display, one or more alternate video program sources, plus hi-fi audio components centered around an audio/video receiver. A/V receivers contain stereo FM-AM tuners, a stereo amplifier and input/output jacks for unified control of all of the video and audio feeds to the TV and external speakers. Some A/V receivers also have surround-sound decoders and four-channel amplifiers.

Consumer can piece together a home theater system by selecting individual parts offered under many video and audio brands. To make the task somewhat simpler, many manufacturers offer a variety of complete packaged systems, along with the cabinetry needed to house them. Pricing ranges from several hundred dollars to several thousand, depending on the features and quality levels of the included components. Some offer the added advantage of a unified remote control, a single hand-held unit that operates all of the performance and switching features of each component in the system.

Videocassette Recorders and Players

The first major new in-home video program source for the television receiver since the advent of cable TV was the videocassette recorder (VCR), first introduced in 1975. It is estimated that more than 70% of all U.S. TV households have a VCR. Because of the speed with which the VCR achieved this high market penetration, unit sales of home decks have leveled off over the last three years. However, a rapidly growing market for replacement VCRs among consumers who purchased sets in the start-up years, and the development of a demand for second and even third VCRs in homes, is expected to keep sales strong well into the future.

Most home and portable VCRs now in use conform to either the Beta or VHS standard, and use half-inch tape in easy-to-load cassettes. First introduced in 1984 were VCRs designed to the new 8mm Video format, which uses a cassette

Factory Sales[1] of Video Cassette Recorders (Thousands of Units[2] and Dollars[2]); United States, 1981-1990

TABLE 1-11

YEAR	VCR DECKS		PORTABLE[3]		CAMCORDER	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981						
1982						
1983	3,374	1,576,370	753	585,939		
1984	6,966	2,897,856	915	687,165		
1985	10,683	3,771,133	586	402,155	517	565,268
1986	12,167	3,893,440	167	85,003	1,199	1,279,333
1987	11,627	3,441,592	*	*	1,604	1,650,516
1988	10,676	2,786,436	*	*	2,057	1,982,948
1989	9,805	2,637,545	*	*	2,271	1,993,938
1990	10,117	2,438,197	*	*	2,962	2,260,006

[1] Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
[2] Unit and dollar figures for table model and portable not available prior to 1983.
[3] Camcoders included in "portable" prior to 1985.
*Portable included in VCR Decks.
SOURCES: EIA Marketing Services Department, U.S. Department of Commerce.

about the same size as a standard audio cassette and tape just eight millimeters (about a quarter-inch) wide. While the small cassette size makes the 8mm particularly suitable for portable applications, home VCRs in that format are available as well.

In all formats, even the most basic home models offer electronic tuner-timers and such special effects as freeze-frame and visible forward and reverse picture scan. Optional step-up features include wireless remote control, variable slow and fast motion, unscrambled cable channel reception, expanded programmability and on-screen function display. The most technologically advanced models include digital solid state memories for such special effects as picture-in-picture for simultaneous viewing of two program sources at once, freeze, variable slow motion, stored image recall, picture polarization and a multiple sequential still frame display that can call up and continuously refresh images from all available TV or cable channels. Also available are decks with log shuttle frame selection dials and other special editing capabilities. New Super VHS and ED (Extended Definition) Beta models provide sharper, clearer pictures.

Full quality stereo audio playback, as well as the recording of stereo broadcast and cable TV programming is offered by Beta and VHS Hi-Fi and digital audio 8mm format home decks which also are equipped with Multichannel TV Sound tuners. Helping boost consumer demand for stereo VCRs, in addition to the widening availability of stereo TV programming, is that most new movies released on pre-recorded videocassettes come with stereo sound tracks. It is estimated that stereo was included as a feature in about 20% of all home VCR decks sold in 1990, and that stereo penetration will rise again in 1991.

A variation on the VCR is the videocassette player (VCP). Generally priced lower than full-function VCRs, VCPs appeal to existing VCR owners considering buying a second set, and to non-owners interested only in buying or renting prerecorded videocassettes. Several manufacturers have started marketing color TVs with VCPs and even built in VCRs.

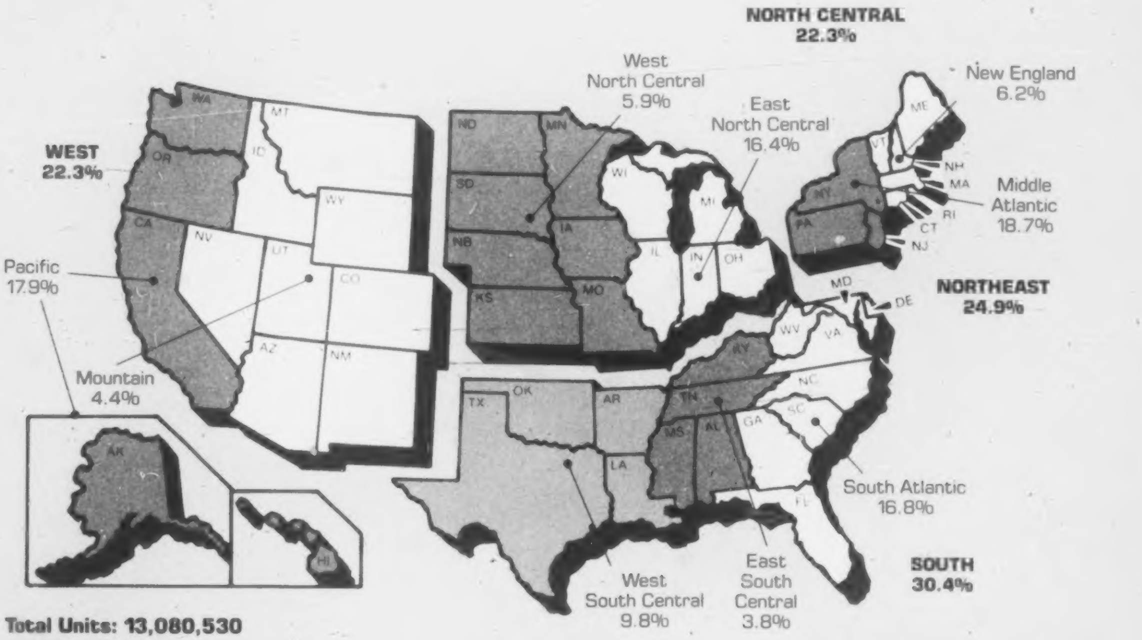
Now emerging as a popular option for consumers looking for a new TV or VCR is the TVCR, a two-in-one space saving and easy to use combination product. TVCRs are available in battery portable models with 5" and 6" screens, as well as in table models with 13", 14", 19", 20" and even 27" pictures. Some smaller size models can be operated from 12-volt power sources, making them suitable for use in boats, campers and recreational vehicles. Most feature remote control and include many of the same programming and convenience features found in stand alone VCR decks.

Camcorders

The camcorder, a one-piece camera-VCR combination, has nearly totally replaced the two-piece portable VCR systems in the marketplace. Camcorders are available with such advanced features as power zoom, automatic focus, variable speed electronic shutters, interchangeable lenses, built-in titling capability and digital memories for a variety of special effects. In 1990, the industry sold nearly 3 million camcorders.

Camcorders are purchased primarily by consumers who already own home VCR decks and are interested in a simple

Estimated Total Sales to Dealers of Videocassette Recorders[1] by Region (%); United States, 1990 **FIGURE 1-D**



Total Units: 13,080,530

[1] Includes camcorders.

Imports of Video Cassette Recorders[1] (Thousands of Units and Dollars); United States, 1981-1990

TABLE 1-12

YEAR	UNITS	DOLLARS[2]
1981	2,000	999,725
1982	2,462	1,031,966
1983	4,760	1,605,771
1984	9,377	2,852,737
1985	16,262	4,165,103
1986	17,605	4,403,711
1987	13,305	2,895,846
1988	11,696	2,506,246
1989	16,909	4,707,675
1990	15,856	4,355,599

[1] Includes recorder/players other than consumer-type.
[2] U.S. Customs Value.
SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Blank Video Cassettes (Thousands of Units and Dollars); United States, 1982-1990

TABLE 1-13

	RETAIL DISTRIBUTION		INDUSTRIAL AND BULK DISTRIBUTION		TOTAL SALES	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	24,672	279,674	8,857	77,766	33,529	357,420
1983	60,368	485,926	14,635	94,516	75,003	580,442
1984	133,185	770,555	33,284	161,376	166,469	931,931
1985	233,021	1,054,825	60,638	229,704	293,659	1,284,529
1986	296,253	1,234,689	71,138	245,526	367,391	1,480,215
1987	273,830	1,005,916	46,585	142,788	320,415	1,148,704
1988[2]	296,947	935,667	43,621	115,270	340,568	1,050,937
1989[3]	285,571	923,071	51,099	126,977	336,670	1,050,048
1990	338,238	948,240	43,031	100,073	381,269	1,048,313

[1] Includes factory sales to distributors and factory direct sales to dealers. Excludes sales to duplicators.
[2] Includes 8mm videocassettes.
[3] Includes 8mm, S-VHS, VHS-C, & S-VHS-C.
SOURCE: EIA Marketing Services Department.

Production and Sales of Camcorders (Thousands of Units); United States, 1986-1990

TABLE 1-14

YEAR	FACTORY PRODUCTION[1]	FACTORY SALES[2]	SALES TO DEALERS[3]
1986	1,245	1,199	1,169
1987	1,623	1,604	1,604
1988	2,309	2,057	2,044
1989	2,210	2,271	2,286
1990	2,746	2,962	2,962

[1] Includes domestic production and imports.
[2] Includes factory sales to distributors and factory direct sales to dealers.
[3] Includes distributor sales and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

to use, lightweight portable for electronic photography. Camcorders are available in all formats—full-sized VHS and Beta as well as the compact VHS-C and 8mm. New Super VHS, Super VHS-C, ED Beta and High Band 8mm record and play back pictures with a horizontal resolution of between 400 and 450 lines, and provide a picture quality that exceeds broadcast standards.

Full-size VHS models, those which record on standard VHS videocassettes, hold the largest individual format share of the U.S. camcorder market. This is probably because of their direct compatibility with most home VCRs. But sales of the compact formats (VHS-C and 8mm) are the fastest growing, as their smaller size and lighter weight make them easier to carry around to family gatherings and special events. In 1990, for the first time, sales of compact camcorders as a group, exceeded those of full-size VHS.

Personal Video

In much the same way that portable headphone tape players and radios opened a whole new world of personal audio, a new generation of portable, and even pocketable, personal video products are expected to create a new way of program viewing. Personal videos combine a VCR with a 3-inch to 4-inch color liquid crystal display for viewing on the go. Personal videos with full-size VHS and 8mm video format VCRs are already available, and models using VHS-C are expected to be introduced this year.

Personal videos are designed for AC, battery or 12-volt operation and contain tuners so they can be used for watching and/or recording TV programs as well as for viewing prerecorded material. While VCRs afford the opportunity of watching any program at any time, personal video products extend that advantage to include "anywhere."

Still Video Cameras

The newest development in video recording, the still video camera, is the snapshot equivalent of the camcorder. Just as the camcorder has all but replaced the 8mm film camera for home movie making, the still video cameras is expected to become the still photography system of choice for large numbers of shutterbugs.

Still video cameras available for sale to consumers today use a 2-inch magnetic disk that can hold either 25 full-frame (525-line) or 50 field (reduced resolution) images. Some cameras can record sound in addition to pictures, enabling the user to include about 10 seconds of narration or sound effects with each image. A new generation of still video cameras, currently priced strictly for the professional market, stores images on cards containing solid state memories.

The electronic, full-color snapshots can be played back through a TV. Some cameras have built-in playback capability; other require the use of an adapter. Still images can be transferred to videocassette to create home slide shows. The disks can be erased and reused.

Several manufacturers are offering separate disc recorder-players which are used for playback of multiple playback discs as well as to capture still images from TV programs, videocassettes or laserdiscs. Another accessory permits the transmission of still images to a remote disc recorder over the telephone. Also on the market are printers which can produce a full color hard copy of the video snapshot. The printers can be used to capture and print out a copy of a scene from any other video source.

Laserdisc Systems

Similar in format to the audio phonograph, the laserdisc player plays back sight-and-sound through a TV set or video monitor. The laserdisc is designed to be a relatively low-cost, high-quality video entertainment and educational medium. Laserdisc players are simple to operate, and offer random access to various program segments.

Players on the U.S. consumer market today use the light from a low-power solid state laser to read information encoded on the reflective surface of the disc. The most popular players today are multi-function models that are designed to handle conventional digital audio-only CDs as well as 5-inch, 8-inch, and 12-inch laserdiscs, and the latest product—CD-Vs. CD-Vs hold up to 20 minutes of audio-only material plus up to 5 minutes of video. Their ability to provide full frequency digital stereo audio has made disc players particularly attractive to opera, ballet and classical music lovers and an important factor in the market for popular music video recordings.

Video Software

The video software market today has grown in importance to essentially equal the hardware side of the industry. It is estimated that some 325 million blank videocassettes were sold to dealers last year. In addition, consumers are believed to have spent nearly $15 billion to rent and buy commercially pre-recorded videocassettes in 1990. Retailers offer recorded videocassettes and discs for both sale and rental. While feature films are the most popular form of recorder video, a vast new market has opened for specialty programs. They include music videos, children's shows, comedy specials and games, as well as educational and instructional tapes on health, exercise, travel, sports, and home and car repair.

Captioning

The evolution of the TV took another major step forward in 1990 when Congress passed, and the President signed into law, a bill mandating the inclusion of closed-caption decoders in all color sets with screens of 13-inches or larger which are manufactured or imported on or after July 1, 1993. Captions are now regularly transmitted along with most news and prime-time entertainment programming to make TV more accessible to the hearing impaired. The captions, which appear on the screen as text, much like the printed translations often placed on the bottom of the picture of foreign language films, are encoded in an otherwise unused portion of broadcast signal. At present, a special separate and expensive decoder is needed to make the captions visible. As many color TVs already come with the built-in capability of displaying text on the screen, it is believed that the addition of a basic caption display can be made at a relatively low cost.

In 1991, the FCC is in the process of setting a performance standard for caption-inclusive TV receivers. Within the area of the signal used for the transmission of captions, there is room for additional features, such as color, graphics and possible even animation. EIA, as the representative of the TV manufacturing industry, is recommending to the FCC that the basic standard require no more than caption display capability. This, EIA believes, will enable the production of captioning sets at the lowest possible cost, making them affordable to all, without forcing consumers to pay excessively for a feature they may never use. At the same time it will leave manufacturers free to offer models with expanded captioning capability.

The TV captioning decoder law is likely to have an impact that extends well beyond its basic aim of opening programming to a wider audience. Over time, as the number of TV homes with decoder-equipped sets expands, captions could become an important tool for helping youngsters learn to read or the foreign-born to become literate in English. Captions also may offer a new way for broadcasters to deliver emergency announcements or other important messages to viewers, or to provide English translations of foreign-language programming.

Home Satellite Earth Stations

Today television programs are literally being plucked from the stars by viewers using a TVRO (TV Receive-Only) satellite earth station. Such stations make possible direct reception of programs intended primarily for the use of TV stations and cable TV systems. TVRO systems, while gradually declining in price, are still expensive, and a complete installation can run into thousands of dollars. Even so, an estimated 3 million are now in use, and they are particularly popular in remote rural areas where there is limited access to cable and broadcast TV signals. Owners in more urban and suburban areas use TVROs to increase the diversity of programming available to them.

In 1984, Congress passed legislation clarifying the right of individuals to own TVROs and to receive and watch signals being transmitted by satellite. To protect their signals from unauthorized reception, the suppliers of the most popular satellite-fed programming began scrambling their programming. To be able to watch such programming, TVRO owners must have a scrambling decoder or decoder-equipped receiver and sign up for a subscription service. Subscriptions are available for individual program channels or whole program packages. The monthly fees are generally comparable to those paid by cable subscribers for similar services.

The growth of the home satellite receiver population has sparked the start of programming aimed exclusively at TVRO owners. The attraction of specialty subscription services are primarily first-run feature films and special pay-per-view sports and entertainment events. Scheduled to start in 1991 are the first special services transmitting in Ku-band channels, which have higher powered signals than those found in the C-band, where most program channels are now located. In most locations, Ku-band signals can be received using dish or flat antennas only two or three-feet across, so they can easily be mounted in windows or on roof tops. Proponents of Ku-band expect the combination of small antennas and special programming will lead to a vast expansion in the demand for home satellite equipment, and that within a year or two, manufacturers will be offering TV sets equipped with satellite, as well as broadcast and cable tuners.

Video Accessories

A vast array of cables, splitters, switchers, special effects generators, videocassette storage systems, tape rewinders, VCR head cleaners, carts, tables and other accessories designed to expand the performance of home video equipment, or to make it easier and more convenient to use, are available to the consumer.

One of the most popular accessories is the universal remote control, which comes pre-programmed or with the ability to learn the instructions needed to operate at least the most often used functions of several remote video and audio devices, such as TVs, VCRs, cable boxes, laserdisc and CD players.

New to the market are low-power wireless video transmitter systems. A transmitter connected to a VCR or disc player can send the video and audio output to a receiver connected to a TV anywhere in the home, and without wires. Additional receivers can be hooked up so that all the TVs in the home can watch the wireless signal at the same time. Also new is an instant VCR programming adapter. Keying in a code of four to eight numbers, now starting to appear alongside TV show listings in newspapers and magazines, sets the adapter up to instruct the VCR to record the desired program. This same feature will also be included in some VCRs to appear on the market in 1991.

The rapidly growing number of camcorder owners are finding there is a wide variety of accessories tailored specifically for their needs. These include telephoto and wide-angle lens adapters, lens cleaners, tripods, battery powered lights, extra batteries and carrying cases. Bringing camcorders closer to the true photography market are interchangeable lenses usable on models designed to accept them.

AUDIO EQUIPMENT

Audio remains a vibrant product category, in large part because of several powerful forces that continue to stimulate the growth of this oldest segment of consumer electronics. Among these forces are the continued expansion of digital audio in all its configurations, the increased integration with home video in the form of home theater systems and multimedia systems, and the trend towards multi-room systems as well as secondary systems in rooms other than the main home entertainment listening or viewing room.

Audio sales still revolve around the compact disc, the digital audio format introduced in 1983, with the market continuing to shift from single-play models to multi-play models which accounted for 41 percent of all CD players sold by the end of last year. CD players continue to spark a strong upgrade and replacement market in related components such as amplifiers, receivers and loudspeakers, and it has become the dominant factor in virtually every audio category, from components to one-brand systems and even "boomboxes."

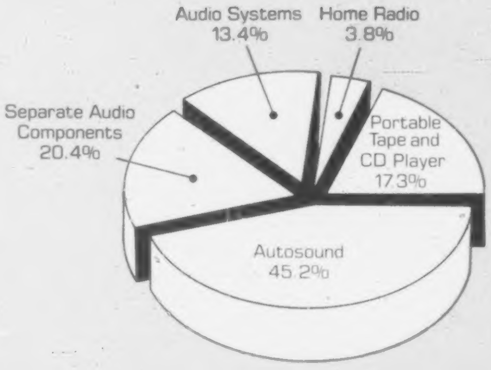
Digital audio tape recorders (DAT) also made their debut during the past year, after several years of controversy between software and hardware producers. While still representing a fairly small volume in terms of numbers, acceptance of digital audio tape equipment and software, in one format or another, is expected to increase substantially during the coming years. Two other factors bode well for the audio segment. Studies undertaken by the industry and by the Federal Communications Commission are expected to result in approval of standards for a national digital audio broadcast system as well as standards for high definition TV (HDTV), which is sure to include provision for digital transmission of the audio portion of future TV programs. Both digital audio broadcasting (DAB) and high definition TV are expected to be introduced before the end of this decade.

With the rising costs of entertainment outside of the home, many consumers are being attracted to the concept of a home theater. Once regarded as too costly for the average consumer, manufacturing ingenuity and volume production has brought the home theater within the reach of millions. Owners of stereo systems are delighted when they learn that such home theater concepts as "surround sound" are easily added to their existing systems. Combination laserdisc/CD players also are easily integrated into home theater configurations, thereby creating new applications for audio components.

One of the most promising segments of home audio is the custom installation market, which has experienced rapid expansion in the past three years, with the advent of a diverse selection of in-wall loudspeakers, switchers and other components used to build comprehensive home entertainment systems, often based around large-screen direct-view or projection TV sets. In-wall speakers lend themselves particularly well to multi-room installations, in which consumers might be reluctant to place floor-standing speakers or even shelf-mounted speakers in secondary locations.

One-brand system sales have endured a bumpy existence during the last five years: following a precipitous decline in 1987, sales rebounded strongly the following year only to fall slightly in 1989 as consumers and retailers de-emphasized the category. Still, sales increased slightly in 1990, helped in part by the incorporation of CD players into such systems. Mid-sized one-brand systems that fit neatly on a shelf but provide excellent sound quality have also helped to popularize and

Distribution of Factory Sales of Audio Equipment by Type (%); United States, 1990 **FIGURE 1-E**



Total = $9,502 Million

SOURCE: Table 1-1.

revitalize sales of one-brand systems. In 1990, sales of one-brand systems increased by approximately 8% and the number of units that will be sold in 1991 is expected to remain about the same, at 1.6 million.

During the last two years, autosound sales have been stimulated primarily by in-dash CD players and trunk-mounted CD changers. Several companies have also begun marketing in-dash DAT players as well as complete AM/FM/DAT combination units. Another factor that is likely to boost car audio sales is the availability of a wide variety of digital signal processing components that can sonically recreate the acoustic environments of concert halls, cathedrals and other musical venues. These components are, in turn, stimulating sales of multiple speaker component car audio systems.

On the downside, analog phonograph turntable and cartridge sales continue to decline as consumers turn to digital program sources such as CD and DAT. That falloff, however, will be more than offset by growth in other segments of audio. The entire category increased by 3% in 1990 and is expected to increase by approximately 2% in 1991.

Advent of Digital Audio

Audio sales prior to the introduction of the first compact disc player in 1983 were at best flat, and the category suffered more than most other areas of consumer electronics during the economic doldrums of the early '80s. But the digital compact disc has revitalized audio, and the expansion of digital audio into new configurations is carrying the digital revolution into virtually every facet of music reproduction.

Before CDs, sound was played back in analog form: turntable cartridge needles, traversing back and forth along grooves cut in a vinyl record, or tape deck playback heads, by sensing the variations in the electric signals recorded on magnetic tape, recreated sound wave and frequency patterns. But limitations in the technology, including imperfections on the surface of record albums and ambient tape hiss inherent in blank audio tape, often masked subtleties in the music and marred the listening experience.

Digital recording and playback eliminates those problems. Digital audio recorders "sample" the music which is recorded at specific points on the sound wave as binary numbers, just the way computers store information. Those "bits" of information are read on playback by the optical laser in a CD player or the playback head in a DAT deck and reconverted into electrical signals. This is why CD players and DAT recorders can also be modified to serve as computer storage devices. Digital audio can re-create a wider, dynamic range of music than is possible with analog audio with a much cleaner sound. Although some audio purists complained that the first generation CD players had a "harsh" sound, those criticisms have been addressed with the more sophisticated sampling techniques and digital to analog converters of current players.

A standard 4 3/4- inch compact disc also can store more music—up to 75 minutes—than an analog record album. In the last two years, a single play, 3-inch disc, which can store up to 20 minutes of music, as well as compact disc-video, which combines analog video with digital audio on 5-, 8-, and 12-inch discs, have broadened the use for compact disc. While prices have declined substantially from the first $1,000 plus players of 1983, the mid- to high-end of the category remains strong as evidenced by the growing popularity of multi-play CD changers and remote controlled models. Still, the average stand-alone player sold for less than $250 at retail in 1990.

The stand-off between DAT hardware manufacturers and the recording industry was resolved in July of 1989 when the two groups agreed on a copy-limiting system that permits single-generation digital-to-digital recording from digital program sources such as CDs onto digital tape. The Serial Copy Management System (SCMS) prevents copies from being made from those first-generation copies. While hardware makers and the recording industry agreed to push for legislation mandating the use of SCMS in DAT recorders, such legislation has yet to pass in the United States. Nevertheless, several manufacturers, having voluntarily complied with the agreement, now offer DAT recorders that incorporate the SCMS feature. While sales in 1990 were limited by production capacity and relatively high initial prices, sales of DAT recorders are expected to accelerate in 1991, especially as additional pre-recorded software becomes available.

Many manufacturers have been developing compact disc recorders—machines that can record and re-record on specially formulated CDs. In many versions, a recording laser heats the metallic surface of the compact disc to record information, and a less powerful laser reads the information for playback. Engineers are working to create a recordable CD system that is fully compatible with the current compact disc standard.

Adding to the overall future impact of digital audio—particularly in building consumer sales of upgrade components—will be cable-delivered digital audio music services. Already, several of these services are in operation on a test basis, providing multiple channels of specialized music and simulcast channels. In Europe, a satellite-delivered digital audio service already is in operation, and several companies in the U.S. are gearing up to provide similar service. In addition, the FCC has begun considering proposals for terrestrial digital audio broadcasting, with the goal of adopting a single standard for this service which would augment current AM and FM analog broadcasting systems.

Cable-delivered digital audio is another harbinger of the day when music, from the recording studio to just before the signal is sent to a loudspeaker in someone's home, will be digital. Most albums already are recorded and mastered digitally, and home audio manufacturers have developed a wide range of digital audio components that pass a signal from CD player to preamplifier to amplifier digitally and only convert to analog before the speaker outputs.

Add-On Components

Even as the basic components in a home audio system improve from year to year, manufacturers have developed new products to further sculpt the electronic signal before it is converted by a loudspeaker into sound. Equalizers, perhaps the most popular signal enhancer, allow consumers to reshape the tonal quality of music by emphasizing or diminishing different frequency ranges.

Digital signal processing, on the other hand, can acoustically reshape the music to create different listening environments. DSP electronically re-creates the reflected wave patterns that form the acoustic characteristics of different types of music venues, so that a living room can sound like a cathedral, concert hall, intimate jazz club or even a stadium, at the flick of a switch.

Surround sound has been a key component in the integration of audio and video. Surround sound processors recover the information sent to the two rear audio channels and in some cases the center audio channel present in many movie soundtracks, so that when videocassettes and laserdiscs of those movies are played back the sound fills the room with more of a three-dimensional quality. Consumers, for example, can hear an airplane fly past even as they watch it zoom by on the TV screen.

Surround sound requires at least two more loudspeakers mounted behind the listener or to either side of the listening room. In an ideal surround sound setup for a video home theater, a fifth speaker would be used as a center channel fill-in speaker, and would be placed in front of the video screen to insure that actors' dialogue remains centered on screen. Surround sound systems used in home video applications may also use a sixth speaker that serves as a sub-woofer, to reproduce those thunderous bass sounds associated with some blockbuster action movies. Many surround sound processors incorporate the necessary amplifiers for these extra speakers. Makers of integrated, all-in-one receivers are now offering models that incorporate not only the necessary surround sound decoding circuitry, but also the extra amplifiers required for the extra speakers.

The next stage after surround sound is full three-dimensional sound. Several developers have built devices that will restore the spatial cues necessary to create a three dimensional sound stage, where sounds are arrayed front to back and left to right as they would be in a live performance. Some 3D sound systems have already been built into color TV sets for a home theater feel.

Packaged Audio Systems

The all-in-one table model audio system called a "compact" has been a mainstay of the industry for some two decades. Usually comprised of a turntable mounted in a cabinet with radio tuner/amplifier, plus cassette or cartridge tape facilities, and/or compact disc, these units are relatively inexpensive, simple to install and operate, and easy to sell. But alternate forms of audio systems have been gathering strength in the retail marketplace. Among the alternatives are complete audio systems produced by a single manufacturer and sold as a unit, complete with a "rack"—a wooden enclosure for the individual elements of the system. Most often called "one-brand" or "uni-brand" systems, these ensembles are for those who want high-quality audio without having to match up components made by different companies, or without having to learn about performance specifications in order to make a buying decision. Such systems—like compacts—are also easy to install and operate.

Two other types of all-in-one uni-brand systems are becoming popular with consumers and dealers. One is the mini or micro component system, made up of units half—or less—the size of traditional audio components. Although small, such systems provide the full complement of features common to traditional size components. The basic difference at this time is that amplifier power outputs are smaller than those of regular size amplifiers. The micro/mini systems are especially appealing to those with limited space for equipment and those who want audio equipment to be minimally visible in home decor.

The other all-in-one system format is the so-called "midi" system, made up of components sized between traditional models and micro/mini units. These "happy medium" systems satisfy those looking for smaller equipment, but have enough heft to satisfy the big-is-better syndrome. They also satisfy those seeking high amplifier power outputs.

Audio Accessories

Sound reproduction has evolved over the years, and so too have the accessories that provide extra convenience and extend the lifespan of audio systems. No matter how sophisticated the hardware and software, consumers still have to find furniture to hold it, cleaners to maintain it and add-ons to make everything easier to use.

Although compact discs are generally thought virtually indestructible, smudges and dirt on the surface of the disc can sometimes cause glitches, so manufacturers have developed various cleaners and cleaning solutions for CDs, just as they have in the past for records and cassettes.

Other convenience products include universal remote controls that can replace the separate remotes from different audio components, timers to turn components on and off at

Factory Sales[1] of Audio Systems (Thousands of Units and Dollars); United States, 1981-1990 **TABLE 1-15**

YEAR	COMPACT SYSTEMS		COMPONENT SYSTEMS		TOTAL	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981	2,739	630,752	200	89,291	2,939	720,043
1982	2,218	428,157	319	144,659	2,537	572,816
1983	2,623	452,200	403	178,281	3,026	630,481
1984	1,678	245,989	1,540	729,760	3,218	975,749
1985	2,532	324,965	2,335	1,046,607	4,867	1,371,572
1986	2,690	319,979	2,158	1,050,295	4,848	1,370,274
1987	2,315	326,467	1,469	721,683	3,784	1,048,150
1988	3,049	336,383	1,666	888,653	4,715	1,225,036
1989	2,878	470,304	1,438	747,080	4,316	1,217,384
1990	2,447	465,836	1,557	804,159	4,004	1,269,995

[1] Includes factory sales to distributors and factory direct sales to dealers.

[2] Not available after 1980.

SOURCE: EIA Marketing Services Department.

predetermined times, speaker stands to raise loudspeakers off the floor for better sound, racks and other furniture to hold components, and storage devices for records, CDs and tapes.

Headphones remain a standard part of many home audio systems, and consumers now have a choice of several different configurations and styles. Open air headphones, where a soft foam cushion fits on each ear, have grown in popularity in recent years, due in large part to their use in personal stereo systems, though the traditional cup variety, which surrounds the ear in a soft shell remains the choice of many consumers.

Audio Tape Equipment

The Philips audio cassette and cassette recorder is the venerable champion of a format battle that once included as many as four separate tape recording and playback systems consisting of: reel-to-reel, eight-track, microcassettes and El cassettes. Reel-to-reel decks and eight-track players still sell in small quantities, but the El cassette is now a museum piece, and microcassette manufacturers long ago abandoned plans to build hi-fi versions of the product.

More important, the cassette recorder has spawned uses far beyond the original imaginings of tape equipment manufacturers. Cassette recorders, or in some cases play-only models, can be found in homes and cars and have become most popular as battery powered portable models with either built-in stereo loudspeakers or headphones for private listening.

In the home, so-called dual-well recorders, that incorporate two record and playback mechanisms for dubbing from tape to tape, have far surpassed single-transport decks, and now outsell them by as much as three to one. Cassette decks also now incorporate microprocessor controls that make recording and playback easier and more exact.

Cassette decks have also benefitted from advances in blank tape technology as well as noise reduction circuitry. The latest blank tapes, in particular metal formulations, can pack in more information for a cleaner, richer signal.

Dolby* noise reduction, though, is generally credited for elevating cassette recording into the high fidelity realm. First Dolby B and then Dolby C reduced the level of audible tape hiss and extended tape headroom to prevent oversaturation distortion caused by intense music passages. Cassette recorders equipped with the latest Dolby noise reduction circuitry, Dolby S, rival digital audio gear in performance and the new circuitry may extend the life of the analog cassette deck through the next decade.

Dolby S is not offered as a competing system to DAT. Rather, it recognizes the fact that analog tape recorders will be with us for several years to come. That being the case, Dolby S represents a further ongoing improvement in analog tape recording technology. In terms of its performance, Dolby S does offer greater dynamic range than either Dolby B or Dolby C noise reduction systems. Dynamic range, when applied to tape recording terminology, is the difference between the softest and loudest sounds that can be recorded and reproduced from a tape. (*Dolby is a registered trademark of Dolby Laboratories, Inc.)

Early this year, the giant Philips Company of The Netherlands, inventors of the analog cassette format, announced development of a digital tape cassette format that differed substantially from DAT. Dubbed Digital Compact Cassette, or DCC, this system employs cassettes that are the same size as standard cassettes. Furthermore, tape recorders and players designed to record and play digital audio in the DCC format would also be able to play back ordinary analog cassettes that consumers might have accumulated over the years. Other advantages claimed for the DCC format are the fact that it can use tape formulations similar to those used in better analog cassette machines. Such tape is likely to be considerably less expensive than the special metal-particle or metal evaporated tape required in DAT recorders. Still another advantage claimed for DCC is the ability of software producers to use high-speed duplication methods to produce pre-recorded software for this medium. As of now, DAT requires real-time duplication, though high speed duplication may also become possible for DAT software in the near future.

DCC machines are not expected to be available until well into 1992. Initial prices for these machines are likely to be equal to those of DAT recorders, but Philips maintains that, ultimately, the price of DCC machines will be low enough to make DCC a mass consumer item, eventually replacing the familiar analog cassette. Philips regards DAT as ideal for semi-professional and professional studio applications, but maintains that DCC will be the preferred form of digital recording to replace the long-lived analog cassette.

Autosound

While car makers struggle to make their product quieter inside and out, car stereo manufacturers continue to explore new levels of gut wrenching hi-fi sound swirling around the passenger compartment. Megawatt-powered shootouts between car stereo installers have become popular events around the country, often with large loudspeakers replacing back seats, and power amplifier wattage extending into the upper reaches of three digits.

The cassette, which overtook eight-track players in popularity in the late '70s, is still the playback medium of choice among consumers. But car CD players are quickly catching up, both as in-dash CD/receiver configurations and as multi-disc changers mounted in the trunk with in-dash control panels.

Trunk-mounted changers also address the growing need to protect autosound equipment from potential thieves. Security concerns have led to the development of in-dash models that can be pulled out and locked away or carried off when not needed. Some models incorporate a security system; whereby the unit can only be reactivated by punching in the special security code.

Car DAT players, which first appeared as a dealer-installed option on some American luxury sedans, have lagged behind CD players and analog tape decks in large part because of the dearth of prerecorded DAT software.

FM radios remain the single most popular piece of car stereo equipment, and most cars sold today have at least an AM/FM stereo receiver if not a combination unit with radio and either tape or CD playback. Manufacturers are also working on ways to extend the range of FM reception and eliminate multipath distortion and other artifacts.

Taking their cue from manufacturers of home audio equipment, car audio hardware makers have designed digital signal processing systems for use in mobile audio systems. DSP reshapes the music signals from any source (radio, cassette tape, car CD player) to recreate the acoustic characteristics of various music venues, such as concert halls, theaters, discos, and small jazz clubs. Some of these systems include a center front channel to help balance the stereo effect for both the driver and other passengers.

Portable Audio

During the '70s the portable radio began evolving into several new product categories as a result of miniaturization and the evolution of the cassette into a truly hi-fi device. In 1989, two new product concepts showed significant growth: so-called "convertibles" and personal portable music systems.

The convertibles are actually complete portable component stereo systems that can be used both in the home and on the go. Many boost swing-out or detachable speaker systems for enhanced stereo separation. All have stereo FM-AM receivers, most are equipped with stereo recorders, and some even include a small TV screen. Contributing to their popularity is improving quality, as manufacturers try to outdo each other in this regard. Also a factor is the changing lifestyle of so many Americans to whom extensive travel and hi-fi are integral parts of living, with fine sound to be enjoyed in every possible locale.

Personal, or headphone, stereo portables were originally introduced in 1979. Now dozens of firms manufacture and market cassette, radio, CD, and combination products. Their success is evidenced by the large number of users that can be seen virtually anywhere, listening while they walk, jog, bask in the sun, read or ride public transportation.

Last year sales were also strong for personal portable cassette models with record as well as playback capability. Sales of these products are expected to continue strong as more and more consumers recognize the advantage of being able to enjoy entertainment on the move without annoying others.

Radio

Stereo was added to FM radio in 1961, after studies of several systems by the National Stereophonic Radio Committee with EIA participation. A single standard was specified by the FCC.

Factory Sales[1] of Portable Audio Equipment[2]
(Thousands of Units and Dollars); United States, 1981-1990

TABLE 1-16

YEAR	PLAYERS ONLY		RECORDERS/ PLAYERS		RADIO/TAPE/CD COMBINATIONS		TOTAL	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1981	1,933		7,430		10,680		20,043	1,157,082
1982	3,643		6,409		10,611		20,663	970,954
1983	4,502	122,003	6,464	192,906	14,850	786,811	25,816	1,101,720
1984	5,614	128,670	5,349	170,081	17,298	891,821	28,261	1,190,572
1985	3,188	64,352	5,164	137,428	18,955	938,181	27,307	1,139,961
1986	3,517	62,116	5,447	143,027	27,318	1,184,034	36,282	1,389,177
1987	4,082	156,455	5,670	150,229	29,127	1,162,435	38,879	1,469,119
1988	3,973	171,974	6,156	166,572	26,306	1,208,204	36,435	1,546,750
1989	4,978	197,509	5,474	150,819	29,323	1,247,189	39,775	1,595,517
1990	4,656	232,512	5,341	142,345	29,157	1,269,977	39,154	1,644,834

[1] Includes factory sales to distributors and factory direct sales to dealers.
[2] Excludes CD players prior to 1987.
SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Radios by Type
(Thousands of Dollars); United States, 1981-1990

TABLE 1-17

YEAR	HOME RADIOS					
	TABLE	CLOCK	PORTABLE	TOTAL HOME	AUTO	TOTAL RADIO
1981	28,390	199,226	273,597	501,213	1,082,945	1,584,158
1982	22,396	178,211	329,076	529,683	1,048,963	1,578,646
1983	23,425	230,455	311,472	565,352	1,147,937	1,713,291
1984	22,989	299,220	339,107	661,316	1,902,336	2,563,652
1985	14,333	204,346	160,606	379,285	1,566,456	1,945,741
1986	6,608	197,609	203,287	407,504	1,683,033	2,090,537
1987	3,253	219,301	186,784	409,338	na	na
1988	5,755	199,217	172,201	377,173	na	na
1989	14,951	217,118	146,620	378,689	na	na
1990	10,907	196,409	152,383	359,699	na	na

na-Not available.
[1] Includes factory sales to distributors and factory direct sales to dealers.
SOURCES: EIA Marketing Services Department, Ward's Automotive Reports.

Factory Sales[1] of Radios by Type (Thousands of Units); United States, 1981-1990

TABLE 1-18

	HOME RADIOS					
YEAR	TABLE	CLOCK	PORTABLE	TOTAL HOME	AUTO	TOTAL RADIO
1981	1,005	9.087	19,323	29,415	12,883	42,298
1982	808	8,210	23,645	32,663	12,306	44,969
1983	930	12,443	26,123	39,496	12,081	51,577
1984	1,354	16,316	28,783	46,453	15,630	62,083
1985	677	9,968	10,929	21,574	15,497	37,071
1986	337	11,330	13,696	25,363	15,783	41,146
1987	149	13,716	14,245	28,110	na	na
1988	170	12,425	11,028	23,623	na	na
1989	419	15,387	9,447	25,253	na	na
1990	357	11,497	9,731	21,585	na	na

*Includes aftermarket AM auto radios.

[1] Includes factory sales to distributors and factory direct sales to dealers.

Na-Not available.

SOURCES: EIA Marketing Services Department, Ward's Automotive Reports.

and sales of stereo FM receivers grew quickly as FM radio broadcasting spread across the country.

The start of stereo AM radio broadcasting was authorized by the FCC in 1982, but the agency left the choice of a system up to radio manufacturers and broadcasters. Initially, some six systems were authorized, but by now, only two systems have survived. The industry is still in the process of selecting which of these two systems should survive, and as a result, no single standard has been adopted. This situation has discouraged some manufacturers from incorporating stereo AM circuitry in their products. With new emphasis on improving AM broadcast and receiver quality, it is likely that the industry will begin to manufacture more models containing one or both stereo AM circuits. Stereo AM would be particularly welcome in car audio systems, for although stereo FM offers excellent fidelity, its range of reception is limited, at best, to perhaps 50 to 75 miles. By contract, AM signals can often satisfactorily be received hundreds of miles from the transmitter from which they originate.

FM has achieved even greater penetration in the autosound market than it has in home-portable radios, and was featured in more than 90% of new car radios last year. The auto radio also is, initially at least, the fastest growing market for radios with AM stereo reception capability. One of the important first steps in the late '80s was an attempt to revitalize the AM band through proposed improvements in broadcasting and reception technology.

HOME INFORMATION EQUIPMENT

Spurred by the office-at-home boom, sales of home information equipment last year outperformed, in percentage growth terms, both the U.S. economy and the consumer electronics industry as a whole.

As measured in dollar volume, home information equipment sales expanded a robust 9.2% in 1990 relative to the previous year, and EIA market analysts predict that this segment will grow another 5% this year. In fact, home information equipment, which barely received a footnote in industry publications a decade ago, is expected to account for $8.1 billion in 1991—equivalent to nearly *one-fourth* of industry-wide sales.

As far as product forecasts are concerned, continued steady growth is predicted in such categories as home computers, electronic typewriters and fax machines. Perhaps the most dramatic growth percentages, however, will be found in cellular telephones, sales of which more than doubled in 1990 and are predicted to jump another 24% in 1991. With an estimated 25 million Americans already working out of their homes on either a full- or part-time basis, all indicators point to continued expansion of home information product sales in the years to come.

Increasingly, products and technologies developed originally for corporate use have been successfully adapted to the consumer market. If the office-at-home phenomenon has driven sales of personal computers, telephone equipment, photocopiers and fax machines, a parallel market has emerged in *portable* office products. In addition to laptop computers, word processors, cellular telephones, hand-held copiers, portable faxes and digital diaries, some observers believe that the next sales boom could occur in the category of "pocket telephones"—lightweight, moderately priced alternatives to their cellular cousins.

Home Computers

Though home computers have been available since 1975, it was not until 1982 that Americans became what would be called computer conscious. Hobbyists were the first customers, and sales grew slowly from 575 units in the introductory year and finally reached the 100,000 mark in 1978.

Continuing in 1984, the home computer rode the coattails of the home video game. Buyers were quick to recognize the improved game play and graphics capabilities of home computers, and as prices declined, sales soared, peaking at 5.1

Imports of Audio Tape Equipment (Thousands of Units and Dollars[1]); United States, 1981-1990

TABLE 1-19

RECORDERS/PLAYERS

YEAR	AC ONLY UNITS	AC ONLY DOLLARS	AC/DC UNITS	AC/DC DOLLARS	TOTAL UNITS	TOTAL DOLLARS
1981	4,018	349,842	18,457	753,527	22,475	1,103,369
1982	4,404	343,383	15,797	624,626	20,201	968,009
1983	6,687	387,585	14,502	592,504	21,189	980,089
1984	7,068	380,000	17,637	742,616	24,705	1,122,616
1985	5,268	317,150	18,355	759,821	23,623	1,076,971
1986	2,512	198,866	13,336	470,463	15,848	669,329
1987	2,716	199,839	17,418	515,074	20,134	714,913
1988	2,867	198,788	17,264	507,033	20,131	705,821
1989	2,135	206,594	21,530	736,617	23,665	943,211
1990	1,931	204,635	18,827	585,160	20,758	789,795

PLAYERS ONLY (EXCEPT AUTO)

YEAR	AC ONLY UNITS	AC ONLY DOLLARS	AC/DC UNITS	AC/DC DOLLARS	TOTAL UNITS	TOTAL DOLLARS
1981	1,063	46,824	3,108	129,863	4,171	176,687
1982	939	37,953	5,227	176,342	6,166	214,295
1983	697	20,679	7,263	175,209	7,960	195,888
1984	1,071	39,828	12,341	278,128	13,412	317,956
1985	1,418	55,290	12,653	304,385	14,071	359,675
1986	1,516	54,810	13,137	316,351	14,653	371,161
1987	1,522	57,026	22,137	424,963	23,659	481,989
1988	1,776	61,743	21,213	407,122	22,989	468,865
1989	2,578	58,483	32,198	1,181,531	34,776	1,240,014
1990	2,120	58,770	29,909	1,012,953	32,029	1,071,723

YEAR	TOTAL HOME & PORTABLE TAPE EQUIPMENT UNITS	TOTAL HOME & PORTABLE TAPE EQUIPMENT DOLLARS	AUTOMOTIVE TAPE PLAYERS UNITS	AUTOMOTIVE TAPE PLAYERS DOLLARS	TOTAL AUDIO TAPE EQUIPMENT UNITS	TOTAL AUDIO TAPE EQUIPMENT DOLLARS
1981	26,646	1,280,056	10,786	545,003	37,432	1,825,059
1982	26,367	1,182,304	10,512	496,386	36,879	1,678,690
1983	29,149	1,175,977	13,423	640,729	42,572	1,816,706
1984	38,117	1,440,572	16,388	893,657	54,505	2,334,229
1985	37,694	1,436,646	18,483	1,083,562	56,177	2,520,208
1986	30,501	1,040,490	17,956	1,146,560	48,457	2,187,050
1987	43,793	1,196,902	17,407	1,207,103	61,200	2,404,005
1988	43,120	1,174,686	17,680	1,307,300	60,800	2,481,986
1989	58,441	2,183,225	16,519	1,341,175	74,960	3,524,400
1990	52,787	1,861,518	15,375	1,094,154	68,162	2,955,672

[1] U.S. Customs value.

SOURCE: U.S. Department of Commerce.

Factory Sales[1] of Blank Audio Cassettes (Thousands of Units and Dollars); United States, 1981-1990

TABLE 1-20

YEAR	RETAIL DISTRIBUTION UNITS	RETAIL DISTRIBUTION DOLLARS	INDUSTRIAL DISTRIBUTION UNITS	INDUSTRIAL DISTRIBUTION DOLLARS	TOTAL SALES UNITS	TOTAL SALES DOLLARS
1981	172,754	226,930	28,685	15,232	201,439	242,162
1982[r]	155,637	202,417	30,810	17,021	186,447	219,438
1983[r]	215,267	234,007	26,010	14,865	241,277	248,872
1984[r]	228,119	256,468	26,678	18,219	254,797	274,687
1985[r]	250,940	269,760	25,552	14,412	276,492	284,172
1986[r]	303,895	300,257	19,785	12,450	323,680	312,707
1987[r]	402,440	374,638	16,802	11,341	419,242	385,979
1988[r]	378,463	366,853	16,043	11,884	394,506	378,737
1989[r]	404,603	384,366	15,909	10,286	420,512	394,652
1990	427,516	376,150	13,283	9,037	440,799	385,187

[1] Includes factory sales to distributors and factory direct sales to dealers. Excludes sales to duplicators.

[r] Revised.

SOURCE: EIA Marketing Services Department.

million in 1984, as the market for the game-oriented computer faded and manufacturers liquidated their inventories of limited function equipment. Sales have rebounded strongly since 1987.

A more mature computer market emerged in 1986, as manufacturers concentrated on the production and introduction of models for more practical application. Though games are still an important part of the home computer scene, they are no longer the driving factor. About 5.5 million computers were sold for home use in 1990.

Today a personal computer housed in a typewriter-like console and with brain power equal to that of the room-sized multimillion dollar computers of the 1960s, can be purchased for less than $300, though prices run up to $2,000, depending on the functional capabilities, memory, power and accessories included.

The term "computer literate" has become more than a catch phrase to describe those in the know. It is now a requirement for graduation from many high schools and colleges, and some colleges include the cost of a computer for each student in their tuition. "Keyboarding," or how to interact with a computer, is being taught at the elementary grade level.

In the home, computers are used for financial and family function planning, record keeping, educational enrichment, training and word processing. Connected to the telephone lines through a built-in or add-on device known as a modem, computers provide access to outside data banks containing a vast variety of research information, along with business, professional and transportation directories, games and message centers that serve as electronic bulletin boards for computer owners with similar interests. Modems also let computers be used for home shopping, banking and travel reservation services.

Computer Software

The computer is similar to a brain, and like a brain it arrives with an operating system that establishes the ground rules which control its functions. Highly detailed and specific instructions must be fed in before a computer can carry out even the simplest task. These instructions are computer programs, commonly called software. Some computers come with software already built in for such common applications as word processing.

Software is available in various forms. Software programs are usually written for specific brands of personal computers, and as a result are not interchangeable. Though games with realistic action graphics are what sparked consumer interest in computers, the market for a new class of interactive strategy games, some of which offer only a text display, is rapidly growing. Utility programs for word processing, accounting, home management, budgeting and personal financial planning are now best sellers.

Computer Accessories

The more a consumer does with a computer, the more accessories are needed to get the job done properly. More expensive computers come with a disc drive for storage, a monochrome or color display monitor and a modem. Less costly are basic computer consoles which are adapted to playback through a TV set. Dealers frequently offer the basic models, along with the most needed accessories, in attractively priced combination packages. In addition, there are lap top computers, printers to transfer words and figures to paper, plotters for graphics and charts, light pens, touchpads, and special computer furniture.

Dedicated Word Processors and Typewriters

The market for portable electronic typewriters is expected to continue to show steady growth. Several manufacturers estimate that 3.2 million electronic typewriters were sold in 1990.

Manufacturers of portable typewriters are now bringing advanced office-machine features to mass market machines at affordable prices. Word processing functions, liquid-crystal displays and spell-checking features can be found on inexpensive models available to consumers. Pen plotters are also being incorporated into electronic typewriters. These models can create charts and graphs, in addition to typing test. Despite these added features, drastically declining prices, changing distribution channels and steady growth in word processor sales have resulted in flat unit sales.

The new word processors designed for home rather than office use are the most advanced home electronic typewriters. These products offer more functions than regular typewriters and are easier to use than computers. Features such as CRT display and removable magnetic memories are available in personal word processors. The growth rate for portable typewriters and word processors is predicted to continue at 5-10% annually throughout the decade.

Facsimile Devices

Compact facsimile devices, or "fax machines," now offer a number of special features to consumers at reasonably low prices. Some of the available features include automatic reduction, on-hook dialing, contrast control, redialing/pause function and fine transmission mode. Most units are compact and lightweight, yet are able to accept standard-size documents and transmit at very high speeds.

Analysts point to the growth in office-installed fax machines as the key to further market penetration, with the rationale that as more businesses and individuals buy faxes, more of the people they communicate with will buy them. Low-end units, which account for a major share of total fax shipments, will continue to grow in share size through 1992, according to Venture Development Corporation. BIS CAP International reports that 75% of the fax devices sold at retail are being purchased by small businesses, resulting in a 2-5% penetration in the home office market.

Personal Copiers

Personal copiers represent one of the fastest growing categories in home office products. Estimates of personal copier annual sales range from 200,000-400,000 units. There are several reasons attributed to the successful sales of personal copiers for the home. Buyers are attracted to models with lower prices and added features, and personal copiers are now more portable, compact, and colorful. In addition, most personal copiers are convenient, with easy installation and low maintenance requirements. Suppliers estimate that home office penetration of personal copiers has reached 600,000 units.

Telephones

While the period of explosive growth for retail sales of telephones has ended, consumers purchased some 29 million of them in 1990, and the majority were electronic phones that offer the convenience of touch button dialing, even in non-tone dialing areas.

One of the highlights of the past few years has been the introduction of multi-line phones to the consumer marketplace. For home office or just busy home use, these have proved popular with today's busy consumers. Good quality phones range in price from about $25 for basic touch-button or rotary dial models, to several hundred dollars for deluxe microprocessor-controlled instruments that provide such conveniences as automatic dialing of stored numbers, hands-free operations, coded screening of incoming calls for privacy and a digital display for numbers called, and time and length of call.

At the ultra-high end of the home telephone pricing scale are videophones, telephones with built-in TV cameras and picture tubes. These phones transmit still black-and-white TV images over standard telephone lines. Of course, two are needed, one at each end of the line, to carry out video conversations. Videophones offering color and motion transmission should be on the market in the near future.

Battery powered portable cordless phones can be purchased for as little as $50, and an estimated 10 million were sold in 1990. More expensive models have such features as higher powered transmitters for longer range, multiple channels to reduce interference and security codes to prevent unauthorized use.

Telephone answering devices are a growing market. Most consumers are still first-time-buyers, but many people are upgrading their devices to include more features. These devices have become indispensable communications tools in millions of busy households, and an estimated 11 million were purchased in 1990. These automatic message takers ensure that important calls are not missed, and always get the story straight. The more sophisticated models allow users to call in to receive messages and to change the answering message on the master tape. Telephones with built-in answering machines are now available from several manufacturers.

Cellular Telephones

An increased demand for mobile radio-telephones has resulted from the 1984 launch of Cellular Radio service. Areas in which Cellular Radio is offered are divided into sectors, or cells, each with a receiving station that feeds calls into the telephone network. As a car with a cellular mobile phone moves from sector to sector, the call is switched to the nearest receiving station. This provides quality service and increases the number of calls that can be handled at any one time. Pocketable battery-operated portable cellular telephones also are available. Phone fees make cellular suitable primarily for business use. As the number of areas where the service is

Factory Sales[1] of Electronic Accessories (Millions of Dollars): United States, 1987-1990 **TABLE 1-21**

Year	Video Accessories	Audio Accessories	Telephone Accessories
1987	290	360	85[r]
1988	304	375	88[r]
1989	258	392	84[r]
1990	332	275	84

Year	Video Camera/Camcorder Accessories	Computer/Game Accessories	Batteries
1987	na	13	n/a
1988	61	19	n/a
1989	60	35	n/a
1990	70	32	59

[1] Includes factory sales to distributors and factory direct sales to dealers
[r] Revised
na Not available
SOURCE: EIA Marketing Services Department

available has increased and sales have risen, pricing has decreased to consumer-affordable levels.

There are currently a couple of experimental licenses, granted by the FCC, permitting microcell telephony—a hybrid product offering the advantages of both wired and cellular telephones.

Calculators

The evolution of the personal calculator is a dramatic demonstration of how electronics have enhanced the daily lives of all Americans. Early pocket calculators, as revolutionary as they were, actually were a little too large for the average pocket and a little too expensive for the everyday consumer. They used a lot of power, so their batteries had to be changed often. Furthermore, they could do only four things: add, subtract, multiply, and divide.

Today, many calculators are as small as a credit card. Some require no batteries at all because they use solar power. Almost all have built-in memories and special arithmetic functions. Some play music, some actually talk, and some are even equipped with built-in games. There are calculators with built-in printers, and there are models with currency conversion, metric conversion, and even calorie-counting capabilities. They may also include diaries, dictionaries, translators, etc.

Electronic Organizers

One of the newest and most promising information products is the electronic organizer. Building on their expertise in electronic calculator and timepiece technology, a number of consumer electronics manufacturers have introduced so-called "digital diaries" at prices ranging from less than $100 for basic models to approximately $300 for those offering expanded memory as well as optional, credit card-like software.

Just as headset stereo and hand-held TVs offered audio and video "to go," this new product category combines lightweight portability with many of the functions of a computer. These electronic planners offer the busy executive a state-of-the-art data management system that fits conveniently into his or her pocket or briefcase.

With as much as 64 megabytes of built-in memory, these hand-held organizers display calendars, remind you of appointments, help you draft notes and brief memos, store telephone and fax numbers, display the time in your city and cities around the world, file names and addresses of business associates, and, with an optional interface, have the ability to "communicate" with personal computers.

With such an interface, one can upload data from the electronic organizer or, conversely, download useful data from a PC for portable use. Software, which is now available in the form of both RAM cards and floppy discs, offers the consumer or business traveler electronic dictionaries and spell checkers, detailed information on airline schedules and hotel rates, and even wine and horoscope guides.

With the optional software, the memory capability of these electronic organizers can be expanded to as much as 128K—a measure of how much miniaturization has taken place since the days when computers with that much power were the size of a refrigerator.

Accessories

Accessories include automatic dialers, amplifiers, add-on hold button adaptors, extension cords, and wiring cables, plugs, and jacks. In various stages of development are low-cost devices that will change the whole nature of the way telephones are used today. Videophones are adding sight to sound. Computer-like terminals with keyboard and display will bring libraries of information, up-to-the-minute shopping guides, news and travel conditions right into the home.

Communications

Citizens Band two-way radio is an important and mature product that enjoyed a major wave of popularity in 1974-76 when car owners learned truckers were using CBs to exchange information during the gasoline shortage era. Sales peaked at 11-13 million annually. In more recent years, they have held at something under 3 million annually, including mobile and base station models, as well as battery portables. Many of today's most popular models are intended for occasional or emergency use, such as in the case of a stranded motorist.

CB is performing many valuable services and saving uncounted lives. Perhaps its most important contribution is the nationwide Highway Emergency Location Plan (HELP), whose participants constantly monitor CB Channel 9, designated as the emergency channel and reserved for SOS calls when assistance is needed on the road.

Low-power walkie-talkies, intended for two-way radio communications across short distances, are popular gift items for youngsters. They formerly operated within the Citizens Band but now operate on a radio frequency all their own.

Home Security Systems

Approximately 15% of all U.S. households currently have some type of electronic security system installed in their homes, according to manufacturers' estimates. This estimate has tripled since 1986, as consumers have become more concerned with household protection and more aware of the security systems available. Included in this product area are fire protection and burglar detection systems. Although the systems' components vary, they generally have a command center and entry sensors. Additional components include devices to make the household's lights flash on and off, glass break sensors, outside sirens, and signal relays for larger homes. A telephone dialer with central monitoring capabilities is also available. While professionally installed systems have dominated the home-security market in the past, a new generation of Do-It-Yourself (DIY) security products is being introduced. These products are easy to install and much lower in cost than professionally-installed systems.

DIY systems are selling for less than one-third of the price of ordinary systems. The basic DIY security system is retailing at less than $200 and deluxe systems are selling for around $500. In addition to the market for new installations of home security systems, a significant after-market exists among customers who have already been equipped with security systems.

HOME AUTOMATION

The "electronic home of tomorrow," long the province of futurists and science fiction writers, is becoming a reality as we progress in the 1990s.

Although some home automation products have been available for years, their appeal has been limited by their cost and/or limited span of control. These limitations have led to the development of a number of open-ended home automation standards including one spearheaded by EIA's Consumer Electronics Group, which is expected to be finalized during 1991. Manufacturers will soon offer America's homeowners the first consumer electronics products and appliances capable of "talking" to and controlling one another rather than just relying on "smart" switches and outlets such as are available today. The proposed standard is designed to work via all existing household media, including the power line, twisted-pair (telephone) wiring, coaxial cable, radio frequency (RF) and infrared (IR) communications links, and, in the near future, fiber-optic cable.

When given final approval by participating companies and published by EIA/CEG, this home automation standard, currently known as CEBus (Consumer Electronic Bus), will provide what has been described as "a multi-lane highway" designed to permit home products and services to exchange control signals and other information.

With all products equipped with specially-designed computer chips, consumers will be able to perform a wide variety of home automation functions. For example, the homeowner can electronically check his or her security systems before retiring for the night, turn off lights, adjust the thermostat to a comfortable temperature, and switch off the eleven o'clock news or the late movie—all by simply touching the bedside controls, and all without having to program a computer.

From a remote location, the homeowner can regulate the temperature or turn on the lights by phoning the house and punching in the appropriate codes. Also, motion detectors will be able to sense when an elderly relative is unusually still and, absent a response, will automatically telephone for help.

EIA's Consumer Electronics Group has a long and distinguished history of setting engineering standards for new products and technologies. In 1984, for example, EIA/CEG was instrumental in establishing the industry-wide standard for stereo television, for which it was awarded an Engineering Emmy. Because the industry and the Federal Communications Commission (FCC) were able to reach an accord on that technical standard, today nearly one of every four color televisions sold in the U.S. is equipped with built-in stereo.

The infrared and twisted pair sections of the EIA home automation standard were approved as interim standards in early 1991. The interim infrared standard covers the transmission of signals to integrated CEBus products, and the interim twisted pair standard covers, for example, the interfacing of security devices with telephone equipment. Twisted pairs facilitate flexible room-to-room communication. Adoption of the full CEBus standard will almost certainly spawn a host of new, "smart" products, all with common interfaces, which take full advantage of their built-in microcircuitry.

Home automation, when it becomes a marketplace reality, will offer consumers both compatibility and convenience.

ASSISTIVE DEVICES

Disabled individuals can function properly in the workplace when assisted by special devices attached to personal computers, telephones and other electronic office equipment. EIA's Assistive Devices Division (ADD), which was incorporated into the EIA Consumer Electronics Group in late 1989, is comprised of private-sector companies of every size that provide electronic and electronic-related products and services which address the needs of individuals with motor, sensory or cognitive disabilities.

Developing and delivering products and services in the assistive devices marketplace can be challenging as well as rewarding. Customers are spread out geographically and are difficult to locate, market needs are diverse, and the payment system is complex. Membership in the EIA ADD provides an opportunity for companies in the assistive devices marketplace to address their common concerns collectively. Working together, member companies have an opportunity to gain new perspectives on the market and to have a voice in public forums where disability-related issues are addressed.

Helping the Visually Impaired

Many of the products produced by EIA ADD members are designed for communication purposes. For the blind or visually impaired, there are personal computers which have scanners to "read" written materials, transform the words into braille, and either print a hard copy in braille or send braille letters into an electronic display which enables the user to feel the letters one by one. There are also computer screens and software offering large print and high-contrast magnified pages, as well as computers that accept voice commands and allow their users to do word processing, accounting, and even phone someone simply by speaking. And because the disabled population is becoming increasingly mobile, there are braille laptop computers and hand-held personal scanners available.

Systems controlled by voice commands can also help the blind and visually impaired gain independence at home. Home automation has the benefit of enabling disabled individuals to control their home environment through voice commands, timers or remote control of lights, TVs, electrical appliances, security systems, and more.

Tools for the Deaf

Telephone devices and listening aids have greatly improved communication capabilities for the deaf and hearing impaired. Telephone amplifiers enhance the clarity and understanding of speech over the phone and may be left in place on the telephone without affecting its normal use. Tone ringers are available which cause the telephone to ring in a special frequency range which most hearing-impaired can hear, and for the severely disabled there are devices which may be hooked up to lamps or overhead lighting that cause the lights to flash when the telephone is ringing.

Deaf individuals and those with profound hearing impairment can benefit from TDDs (telecommunication devices for the deaf), small printers which hook up to the regular telephone and electric outlets and allow their users to receive printed communications via the telephone. Add-on systems allow for automatic answering machine capability, call monitoring, emergency dialing, and some facilitate the connection to recorded services such as airline reservations, stock information, and electronic home shopping services.

Compact personal amplifiers enable the hearing impaired to hear a television, listen in a group, or communicate in a noisy or reverberant environment, without disturbing others. Telecaption devices can also be utilized with televisions to display text on the screen when viewing a closed caption program.

In an office environment, computers may be equipped to provide visual cues instead of system beeps, and at home, security systems can be programmed to flash the lights when the alarm trips.

Other Assistance

The handicapped community is also comprised of speech-impaired, motor impaired, and cognitively disabled individuals. Each has a special set of needs which are being met by electronics manufacturers. For those unable to speak, there are various voice synthesizers and speech devices which facilitate easy communication. Large-button and specially-keyed computers and telephones ease use for those with motor impairments, and "sip and puff" and voice-activated devices allow for greater mobility of the severely physically handicapped. Speaker phones make telephone conversation possible for those unable to hold a handset, and cordless phones enable individuals confined to wheelchairs to have access to the telephone wherever they may be.

At home, the physically disabled are aided dramatically by home automation. A bedridden individual can control his or her entertainment products, drapery, lights, telephone, water heater, security system, and even answer the door without assistance.

For the cognitively disabled, there are numerous computer software programs which help overcome learning difficulties and allow formerly dysfunctional individuals to learn and to contribute productively to the workforce. There are also devices designed to aid in the care of the cognitively disabled, such as electronic wristbands which alert the caretaker when the individual wanders off unattended.

General Health Care

Electronics and health now go hand-in-hand. Now available for routine in-house use are instant electronic thermometers, easy-to-use blood pressure gauges and highly accurate scales with digital display. Specialized versions of other electronics products, such as calculators and watches, help count calories and check pulse rates. Also available are computer programs for menu planning and videocassettes with informational programs on exercise, diet, baby care and general health tips.

PERSONAL ELECTRONICS

Electronic Watches

The old tick-tick of the mechanical watch has been all but superseded by the silent, split-second accuracy of the electronic timepiece. From plastic-encased digital throwaways costing just a few dollars to high-precision chronographs housed in gold and accented with diamonds, electronic watches are bought by the millions each year.

Electronic and electro-mechanical watches have opened a whole new market, with styles in all shapes, sizes, price ranges, and offering a choice of digital display or what appears to be a traditional dial-and-hand face. They are worn as pendants, pins, on bolo ties and hair barrettes. They are popping up on the sides of novelty purses, backpacks and briefcases. Some are combined with pens, and others come with stick-on backings for fastening to car dashboards, refrigerator doors or next to telephones.

Specialty watches do more than tell time. Some models display the temperature or heartbeat rate of the wearer; function as calculators, stop watches or alarms; show world time; and even play video-like games. Others offer features to calculate distances walked or jogged, to time yacht races, or to calculate average speeds, time of arrival and distance covered.

Toys and Games

The electronic toys and games market includes radio-controlled vehicles, video games, robotic toys and non-video electronic games. The video game sector, which includes video game consoles, plug-in game cartridges, and game programs for personal computers, have become a billion dollar industry. Video games have grown in popularity to the point that one software company even offers an instructional video to help parents choose the "right" video games for their children and to control gametime by integrating it into chores and schoolwork.

A new generation of video game consoles with greater sophistication, spectacular graphics, animation and digitized sound effects led to substantial growth during the last half of the 1980s. Several companies introduced handheld games consisting of approximately two-inch square monochrome or color liquid crystal screens and headphones for stereo sound effects. Competition remains strong with the advance of 16-bit games, which are closer to arcade quality.

Manufacturers also appear to be broadening their customer base by offering new software and accessories targeted to adults. Recently, new interactive-TV products, wireless joysticks and even video game "gloves" have stimulated video game sales to adults by allowing the games to incorporate their own body movements into the action of the game. Adults are also investing in expensive game storage units and locks to prohibit children from using their equipment without supervision.

These trends led to hardware and software sales estimated at over $5 billion in 1990, up from $3.4 billion in 1989. Another five percent increase in sales is expected for 1991.

Musical Instruments

Electronic keyboards automatically come to mind whenever mention is made of electronic musical instruments. The electronic keyboard celebrated its Golden Anniversary in 1989, and during its first 50 years it evolved from a basic keyboard into a complex instrument with the ability to synthesize the voices of all the instruments in a symphony. Advanced models on the market can memorize virtually any sound—including a dog's bark, car horn or telephone ring—and reproduce it as part of a composition.

In addition to diversity of sounds, electronic keyboards also offer consumers the benefit of real value. With models ranging from as low as $50 to those costing several hundred dollars, the electronic keyboard has become a mass market item for everyone from beginners to expert composers. Their compact size assures portability and also makes it possible for individuals who do not have enough space in their home for a full-size piano or organ to enjoy creating music. And for parents, the electronic keyboard offers the option of a lower cost investment in their children's musical training.

Electronic musical instruments are by no means limited to keyboards. Electronic drums, guitars, horns and other synthesizers are available, and popular musical accessories include wireless microphones, voice synthesizers and mixer mics to add music to home videos. There are also a number of computer software packages which enable a musician to hook up an electrical instrument to a computer and compose music for an entire symphony. Other software allows users to play a tune on an electronic instrument and have the computer translate the tune into sheet music.

Electronics for Children

A vital new market has opened in recent years for electronics geared toward the very young. With many children learning to use computers in their pre-school years, instructional programs and computer games are now being offered for children

Imports of Consumer Electronic Products (Thousands of Units and Dollars[1]); United States, 1981-1990

TABLE 1-22

	COLOR TELEVISION		MONOCHROME TELEVISION	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS
1981	1,984	501,424	6,246	404,425
1982	2,228	545,584	5,521	343,648
1983	4,849	797,240	5,281	292,104
1984	6,441	1,089,266	6,462	360,347
1985	7,685	1,113,770	6,381	349,111
1986	9,755	1,525,192	6,556	325,323
1987	9,886	1,499,983	5,220	263,024
1988	8,289	1,366,958	3,050	158,097
1989	10,400	1,746,758	3,014	165,885
1990	9,332	1,659,132	2,211	123,446

	HOME RADIOS		AUTOMOBILE RADIOS	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS
1981	33,514	549,433	3,567	144,253
1982	33,744	543,221	3,605	167,337
1983	38,637	567,429	4,507	257,495
1984	48,935	655,615	4,871	299,718
1985	43,501	609,763	5,035	311,357
1986	40,455	532,987	3,665	209,155
1987	39,238	583,577	2,999	168,696
1988	36,894	565,452	3,067	184,118
1989	40,256	637,845	2,596	198,542
1990	35,198	506,777	1,830	173,221

	HOME AUDIO EQUIPMENT	
YEAR	UNITS	DOLLARS
1981	30,083	1,478,266
1982	28,489	1,342,499
1983	31,685	1,337,067
1984	40,703	1,629,302
1985	40,981	1,822,553
1986	33,548	1,807,066
1987	47,435	2,343,086
1988	48,012	2,784,988
1989	46,984	2,381,782
1990	40,544	2,170,121

	AUTO TAPE PLAYERS		VIDEO CASSETTE RECORDERS/PLAYERS	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS
1981	10,786	545,003	2,000	999,725
1982	10,512	496,386	2,462	1,031,966
1983	13,423	640,729	4,760	1,605,771
1984	16,388	893,657	9,377	2,852,737
1985	18,483	1,083,562	16,262	4,165,103
1986	17,956	1,146,560	17,605	4,403,711
1987	17,407	1,207,103	13,305	2,895,846
1988	17,680	1,307,300	11,696	2,506,246
1989	16,519	1,341,175	16,909	4,707,675
1990	15,375	1,094,154	15,472	4,223,254

[1] U.S. Customs value.

SOURCE: U.S. Department of Commerce.

as young as three years of age. Certain computer software even lets children create their own illustration storybooks.

There are radios, cassette players and recorders, and CD players designed for the younger set, as well as several models with built-in microphones for sing-along fun, or built-in synthesizers to produce percussion or animal sounds. Also available are easy-to-use musical instruments, electronic word games, math games, and watches to teach children how to tell time. For the younger ones, there are talking bears and animated dolls; and for older kids, there are electronic dictionaries, remote-controlled cars and robots, and more sophisticated electronics. Walkie-talkies and various electronic tub toys round out the children's electronics market, which has become a major section of the consumer electronics industry, with products ranging in cost from around $30 to $200.

Exports of Consumer Electronic Products (Thousands of Units and Dollars[1]); United States, 1981-1990 **TABLE 1-23**

YEAR	COLOR TELEVISION UNITS	COLOR TELEVISION DOLLARS	MONOCHROME TELEVISION UNITS	MONOCHROME TELEVISION DOLLARS
1981	646	236,295	260	29,730
1982	381	138,939	138	16,632
1983	237	83,804	52	6,770
1984	267	92,632	79	8,044
1985	267	85,806	101	11,561
1986	357	116,955	77	10,947
1987	490	155,795	96	12,335
1988	1,404	404,557	266	25,908
1989	2,549	377,223	765	52,826
1990	2,194	423,108	759	54,561

YEAR	HOME RADIOS UNITS	HOME RADIOS DOLLARS	AUTOMOBILE RADIOS UNITS	AUTOMOBILE RADIOS DOLLARS
1981	560	19,005	775	72,618
1982	413	11,675	758	71,552
1983	279	9,210	742	75,884
1984	484	10,898	816	96,055
1985	523	13,986	685	72,094
1986	760	17,825	802	78,414
1987	1,096	23,391	1,039	100,480
1988	1,978	51,506	2,196	179,436
1989	1,867	43,423	1,332	146,425
1990	2,945	55,217	1,837	253,105

YEAR	HOME AUDIO EQUIPMENT UNITS	HOME AUDIO EQUIPMENT DOLLARS
1981	825	118,696
1982	475	88,407
1983	181	50,699
1984	194	49,211
1985	285	59,738
1986	423	67,911
1987	589	94,723
1988	2,089	234,408
1989	1,715	201,054
1990	1,821	184,290

[1] U.S. Customs value.

SOURCE: U.S. Department of Commerce.

IMPORTS AND EXPORTS OF CONSUMER ELECTRONICS

Imports of consumer electronics were $16.2 billion in 1990, a decrease of 3.3% from 1989. Videocassette recorders/players accounted for approximately 25% of import dollar volume. Home audio equipment accounted for the second largest category with imports of $2.2 billion, while color television imports totaled $1.7 billion. Total dollar values of other import categories can be found in Table 1-22.

Total 1991 exports of consumer electronics amounted to $3.7 billion, a 27% increase over 1989. Exports of color television accounted for just over 11% of the dollar value of total exports. This represented growth of over 12% from exports of color television in 1989. Exports of automobile radios, also showed strong growth, rising 73% to $253 million. Total dollar values of other export categories can be found in Table 1-23.

The trade deficit for consumer electronics was just under $12.5 billion in 1990. This represented a decline of 10% from the $13.8 billion consumer electronics trade deficit in 1989. Imports, export, and the balance of trade for consumer electronics products by country are detailed in Chapter 7, "General Information."

CONSUMER PRICE INDEX

The products of the consumer electronics industry provide double value to the consumer. The consumer electronics industry seeks to increase the quality, reliability, and features of existing products, while continually introducing new and exciting products. The industry is able to provide this at prices that have changed consistently less than the rate of change of the Consumer Price Index for all Urban Consumers (CPI-U) for all items. The year 1990 is a good example. The CPI for audio products decreased 1%, while the CPI for television fell 4%, and the CPI-U rose 5%. What this means is that consumers who purchased products in 1990 not only received better products, but they did so at lower prices.

Annual Consumer Price Index by Product Type (1982-84 = 100[1]); United States 1984-1990 **TABLE 1-24**

YEAR	AUDIO PRODUCTS	TV	ALL ITEMS
1984	97.7	95.5	103.9
1985	94.4	88.7	107.6
1986	91.8	83.2	109.6
1987	93.0	79.7	113.6
1988	91.9[r]	75.3[r]	118.3
1989	94.3[r]	75.8[r]	124.0
1990	93.3	73.1	133.8

[1] 1982-84 base period used is the average over the 36 month timeframe.

[r] Revised.

SOURCE: U.S. Department of Labor

MARKETING CONSUMER ELECTRONICS PRODUCTS

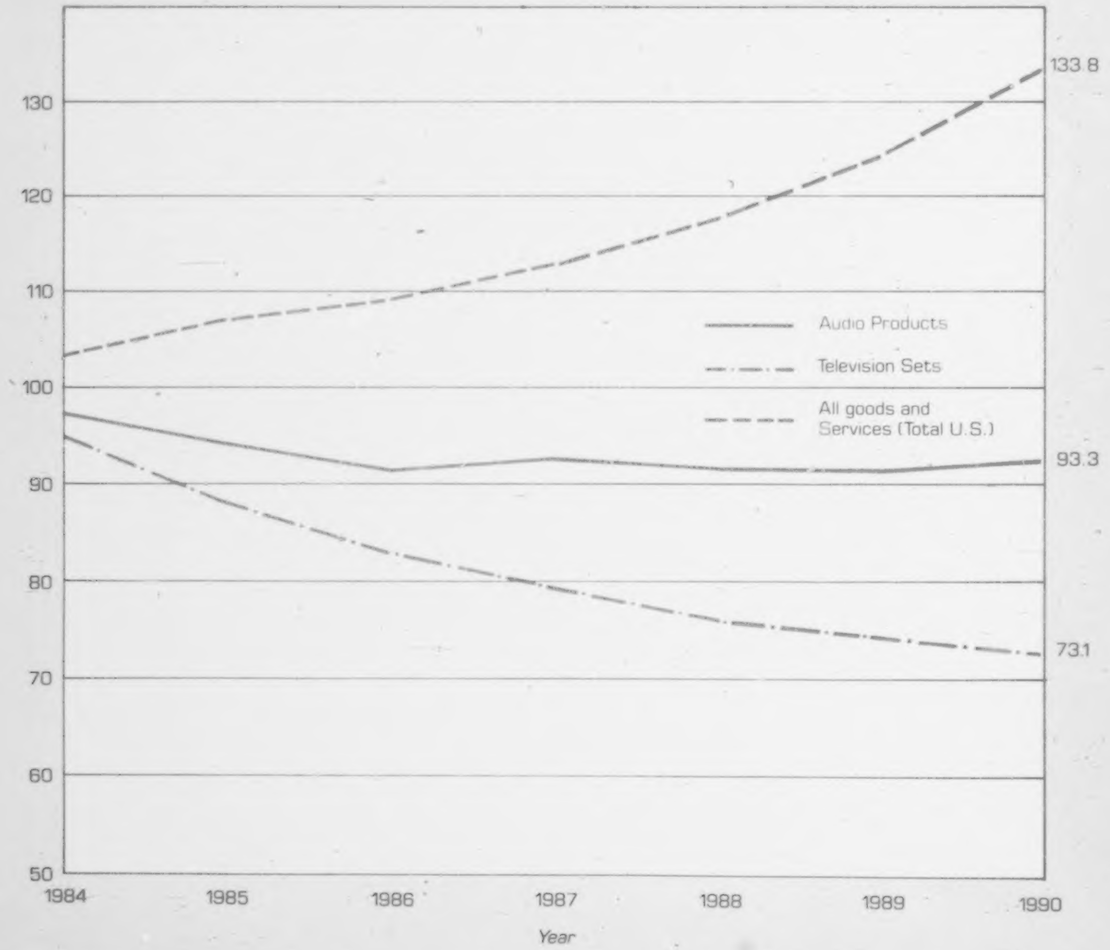
The vast array of consumer electronics products that line the shelves of the tens of thousands of U.S. retail outlets are the result of the combined efforts of a global workforce of business executives, scientists, engineers, production workers, marketing and advertising specialists, and sales personnel.

Entrepreneurs continue to invent new consumer electronics products in basement workshops and garage laboratories, but the reality of the international marketplace is that such one-person breakthroughs are increasingly rare. Today, global companies invest millions, even hundreds of millions, of dollars in research and development of new products and technologies, and then achieve economies of scale with which the small company is hard pressed to compete.

In addition to R & D and cost-of-production advantages, the manufacturer of consumer electronics products often allocates considerable resources for testing prototypes and market research. It is not unusual for a product to go through the design-prototype-field test cycle several times before a decision is made on whether it should be put into mass production and brought to market.

Just as the prospects of the industry are constantly changing, business practices, too, are continually updated to keep pace with new merchandising and distribution techniques. Distribution patterns vary widely among manufacturers. Whereas some employ the "two-step" method of distribution (under which distributors buy from the factory and sell to retailers), others have opted to abandon this approach in favor of moving merchandise directly into a wide variety of retail outlets. Still others prefer a combination of the "one-step" and "two-step" methods of distribution.

Annual Consumer Price Index by Product Type (1982-84 = 100), United States, 1984-1990 **FIGURE 1-F**



Still other marketers sell to dealers through independent "manufacturers' representatives," who typically handle a variety of related lines and perform some of the functions of a distributor without actually purchasing or warehousing the product. Some "reps," as they are called, will do warehousing.

There is also a thriving "private label" business in this country and around the world—the manufacture of specially designed products to carry the brand names of the retail store or other merchandisers.

The emergence of literally dozens of new consumer electronics product categories has given rise to many new forms of retail establishments. Radios, television sets and phono-

Consensus of Estimates

TABLE 1-25

Data contained in the following tables reflect a consensus of estimates provided by EIA Consumer Electronic Group Marketing Service Committee members and independent research firms. These data are not derived from regular EIA Marketing Services Department reporting programs. In all cases, unit activity represents total annual U.S. sales to dealers in thousands of units. All dollar figures represent total annual U.S. factory sales in millions of dollars.

Home Computers and Security and Satellite Earth Station Systems

	HOME COMPUTERS		HOME SECURITY SYSTEMS		HOME SATELLITE EARTH STATIONS	
Year	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)
1982	2,000	1,300	na	na	na	na
1983	4,800	1,950	na	na	na	na
1984	5,100	2,250	na	na	na	na
1985	4,100	2,050	na	600	na	na
1986	3,800	2,890	na	720	235	256
1987	4,000	2,920	na	800	250	304
1988	4,500	3,150	na	900	275	331
1989	5,000	3,500	na	1,000	300	365
1990	5,500	3,795	na	1,150	330	421

Telephones and Answering Devices

	CORDLESS TELEPHONES		CORDED TELEPHONES		CELLULAR TELEPHONES		ANSWERING DEVICES	
Year	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)
1982	2,000	200	3,700	200	na	na	850	110
1983	4,700	400	15,000	525	na	na	2,200	190
1984	6,300	460	24,000	790	25	50	3,000	230
1985	4,000	280	21,000	630	75	115	4,220	325
1986	4,100	295	18,100	561	280	266	6,450	464
1987	6,400	435	15,900	461	300	267	8,800	607
1988	8,200	574	15,200	441	500	430	11,100	755
1989	10,000	700	19,000	532	870	653	12,500	838
1990	9,150	641	18,100	507	2,100	1,260	11,000	671

Estimated Household Penetration by Product (As of January 1991)

All Television	98%	Audio Systems	93%
Color TV	96%	-Compact	61%
Monochrome TV	56%	-Component	53%
Projection TV	7%	Telephone Answering Devices	39%
VCR	72%	Cordless Telephones	34%
Camcoders	13%	Home Radios	98%
Home Computers	28%	Home Security Systems	15%
Compact Disc Players (Home)	25%	Home Satellite Earth Stations	3%

na-Not available.

graphs were once sold chiefly by radio/TV/appliance dealers, department stores and music stores. The audio retail specialist appeared in the 1970s, while during the '80s such innovations as VCRs, camcorders and stereo TVs produced a trend toward video specialization. Similarly, specialty stores have been established for the sale of personal computers, telephone equipment, car audio, and video software. Discount catalog showrooms and consumer electronics departments in traditional stores have also flourished in the $44-billion-plus U.S. retail market for audio, video and home information products.

At one time most major manufacturers made one principal model change a year. Typically, they would introduce their new models to the trade in the late spring or early summer, often at the International Summer Consumer Electronics Show (CES) in Chicago in June. It was at the Summer CES, which is sponsored by EIA/CEG and is open to the trade only, where retailers would get their first look at new products.

Today, however, there is less seasonality to the industry's sales cycle. With the proliferation of categories and the rapid pace of innovation, new products are introduced throughout the calendar year. The Winter CES, held each January is Las Vegas, is now an equally important venue for showcasing new products.

Communications Equipment and Services

The world of electronic communications is expanding continually as users take advantage of new technologies and applications for transmitting voice, data, and video. Not too long ago, voice communication via telephone was by far the predominant technology used by businesses. Today, data communications proliferate and voice communications have been enhanced by features such as voice messaging and automatic call distributing. As standards such as Integrated Services Digital Network (ISDN) become entrenched, the industry — indeed, the world—is moving towards globally connected networks that readily can transmit voice, data, and video signals.

Evolving technologies and standards provide for a growing industry. In 1991, worldwide telecommunications revenue is expected to increase 15% and data communications revenue to jump 20%, creating a $76 billion total, according to *Electronics*.

Changes in the types of communication media also have impacted the size and scope of the market. Satellites, microwaves, and cellular radio allow both mobile communication and long-distance transmission without cabling. Digital technology provides faster, more reliable transmission as does fiber optics, which uses glass or plastic cables to transmit electronic signals. Each of these changes has added to the growing list of potential users of electronic communications technology.

The electronic communications industry loosely can be categorized by the media used to transmit messages, the equipment used to manage transmission, and the technology used by the equipment and the media. This chapter presents an overview of these categories; however, it cannot cover the entire industry in depth. For additional information on data communications, please see the next chapter, Computers and Industrial Electronics.

COMMON CARRIER BUSINESS

Common Carrier exchanges involve probably the most well-known aspect of telecommunications—the telephone companies. The entire business is fairly complicated, consisting of local exchange networks, which offer local phone service; interexchange networks offering long distance services; and specialized networks offering services such as data communications; and the myriad terminal and network equipment used by common carriers and customers.

According to the North American Telecommunications Association (NATA), the total market for telecommunications reached $128 billion in 1989. Of that amount, local exchange

Factory Shipments of Communications Equipment ($ Million); United States, 1981-1990 **TABLE 2-1**

	1981	1982	1983	1984	1985	1986	1987	1988^{r}	1989^{r}	1990^{e}
Communications, Broadcast Studio, Intercom, Search and Detection, Navigation and Guidance Systems and Equipment	23,657^{r}	27,517^{r}	30,525^{r}	35,188^{r}	40,968^{r}	44,269^{r}	46,373^{r}	47,650	48,848	51,375
Telephone and Telegraph Equipment	12,003^{r}	11,613^{r}	11,594^{r}	14,341^{r}	16,127^{r}	15,554^{r}	15,995^{r}	16,055	14,758	15,200
TOTAL	35,659	39,130	42,119	49,529	57,095	59,823	62,368	63,705	63,606	66,575

r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

services accounted for $56 billion and long distance services for $51 billion, while the other sectors, including information services, special data communication services, cellular, and voice messaging and call processing, accounted for $20 billion. NATA forecasts the entire market to reach $175 billion by 1995, with most of the growth expected to be in long distance, cellular, voice messaging, and audiotext.

At least 2,000 companies provide public telecommunications services in the U.S., reports *U.S. Industrial Outlook '91*. During one year these companies switch more than 450 billion calls over a network that links 243 million telephones. Virtually every U.S. business has at least one telephone these days, as do 93.3% of U.S. households.

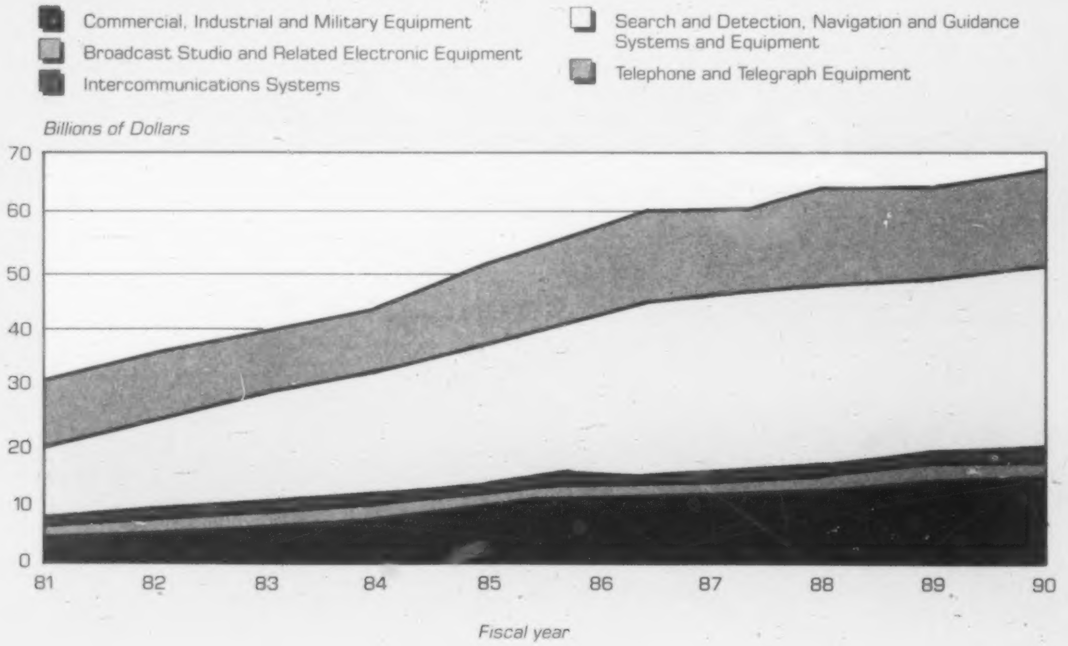
Most of the world's telephone systems are to some degree government controlled or regulated. In the United States and Canada, however, the regulating entities are independent agencies. The FCC, an independent regulatory agency subject to Congressional legislation and appointed by the President, regulates all commercial interstate and international communications activities. Intrastate and local activities are regulated through state public utility commissions, but the initiative for new service and new pricing remains in the hands of the carrier.

In the United States, the telecommunications services industry is undergoing a major restructuring to accommodate the rapidly changing technological and competitive environment. In addition to changes brought about by the divestiture and reorganization of AT&T in 1984, many of the large independent telephone companies have expanded their operations to include cellular radio, fiber optics, satellite services, digital electronic mail systems, and other data communications.

Computer firms also have recognized that information systems must handle text, voice, images, and graphics—not just data processing. Modern business information systems rely on a combination of computer and communications technologies. Various computer, communications, and semiconductor companies are finding it mutually advantageous to combine their technologies through joint ventures, investments, licensing, and other cooperative arrangements. As international barriers erode, more and more joint ventures and alliances are taking place in the international arena. In the years ahead, global connectivity should be a major force for telecommunications growth.

According to *High Technology*, gaining network control has become a priority for some companies who want to establish and maintain reliable voice and data links. Before divestiture in 1984, the "bypass" phenomenon was not possible, as customers could not independently reconfigure the network to meet changing demands. Now, however, some companies are establishing digital links to bypass parts of the public telecommunications network, thus circumventing access charges levied by local phone companies on long-distance carriers. The most common approach is the "service bypass," which involves sidestepping the local analog links by leasing multiplexers (i.e. digital T1 links) from the local phone com-

Annual Factory Shipments of Communications Equipment by Type ($Billion); United States, 1981-1990 **FIGURE 2-A**



SOURCE: Tables 2-2 and 2-4.

Factory Shipments of Communications Equipment by General Class[1] ($ Million); United States, 1981-1990 **TABLE 2-2**

	1981	1982	1983	1984	1985	1986	1987	1988^r	1989^r	1990^e
Commercial, Industrial and Military Communications Equipment	5,583.4^r	6,668.6^r	7,542.1^r	9,157.5^r	10,606.5^r	11,124.6^r	11,394.7^r	12,212.7	13,879.5	15,400
Broadcast, Studio and Related Electronic Equipment	1,446.6	1,543.8	1,464.0	1,475.8	1,561.9	1,553.5	1,608.4	1,804.3	1,848.6	1,900
Intercommunications Systems	1,586.2^r	1,571.5	1,536.7	1,732.0	1,742.6	1,669.6	1,944.2	1,944.3	2,137.1	2,175
Search and Detection, Navigation and Guidance Systems and Equipment	15,040.3	17,733.0	19,981.7	22,822.6	27,057.0	29,921.1	31,425.6	31,689.0	30,982.5	31,900
TOTAL	23,656.5^r	27,516.9^r	30,524.5^r	35,187.9^r	40,968.0^r	44,268.8^r	46,372.9^r	47,650.3	48,847.7	51,375

[1] See Table 2-3 for product detail.
r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

pany. Applicable to long-haul and local needs. T1 integrates voice, data, video, facsimile, and graphics in a single high-speed facility. Now, many companies are moving from complete service bypass to hybrid services that mix public and private networks and equipment. (For more information, see the section on MANs in this chapter.)

Telephone and telegraph equipment consists of network equipment, which is the means of transmission, and customer premises equipment (CPE), which is terminal equipment that sends and receives information. Network equipment includes switching and switchboard equipment, multiplexing equipment, repeaters, line conditioning equipment, and wire. (This chapter does not cover network equipment in detail.) CPE includes telephone sets, key systems, private branch exchanges (PBXs), facsimile machines, telephone answering devices (TADs), and modems. According to *U.S. Industrial Outlook '91*, U.S. shipments of total telephone and telegraph equipment reached $17.4 billion in 1990.

CUSTOMER PREMISES EQUIPMENT

Telephones and Answering Devices

As of March 1990, 93.3% of 94 million U.S. households had a telephone, according to the U.S. Census Bureau. Even with such high household saturation, the market remains steady. EIA estimates put 1990 total factory sales of corded and cordless phones at $1.15 billion; predictions for 1991 show a similar figure, with growth in the cordless market counteracting a slight drop in corded phones.

Telephone answering devices (TADs) should generate interest in the next few years. As of January 1991, 39% of 93.1 million U.S. households had TADs. With the coming of tapeless digital answering devices (DTADs), however, the future is hard to predict. Some industry experts say digital eventually will replace tape, while others are less sure about the timing of the process. Currently, only a few manufacturers offer DTADs while others apparently are waiting for wider consumer acceptance and lower prices.

Caller ID allows phone users to identify the name and/or phone number of callers before picking up the receiver. A controversial telephone feature when introduced in 1989 due to potential invasion-of-privacy issues, Caller ID already appears to be gaining consumer acceptance. According to Research First Consulting Inc., approximately 30 states will offer caller ID in some areas by the end of 1991. A number of manufacturers are beginning to introduce replacement and add-on equipment, hoping to take advantage of both the home and small business markets.

Meanwhile, the market for payphones has shown enormous growth since the 1984 FCC ruling that allowed businesses other than phone companies to connect payphones to the interstate network. NATA says the annual payphone market grew from $35 million in 1984 to $150 million in 1990 and predicts a $215 million market by 1995.

PBX, Centrex and Key Systems

Private Branch Exchange (PBX), Centrex, and key systems fall under the category of on-premises switching equipment. Centrex is leased through a Regional Bell Operating Company (RBOC) and operated offsite by the telephone company's central office (CO), while PBXs and key systems either are leased or purchased to be operated in-house. Key telephone systems usually are used in small- to medium-sized offices with 2 to 120 station sets and provide intra-office links such as intercoms but route outside calls through a central operator. Key systems can be used alone or to complement Centrex or PBX systems, which are much more powerful, having many more lines and allowing outside callers to dial directly. PBX and Centrex systems offer many of the same functions; the main difference being the location of the equipment and services.

The PBX, which was deregulated in 1968, has experienced enormous technological changes in the past two decades. Moving from electromechanical to analog to digital technology, the switching systems now can operate at data speeds up to 64 kilobits per second, support MPU-based (Microprocessing Unit) telephones, and offer features such as integrated call distributors, cost accounting, voice messaging, full data communications capability, and the ability to bridge local area

Factory Shipments of Communications Equipment ($ Million); United States, 1981-1990

TABLE 2-3

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
Commercial, Industrial, and Military Communications Equipment										
Fiber optics systems and equipment	75.0	88.3	275.5	254.0	528.5	636.6	434.3	717.1	778.2	830
Other light communications systems and equipment (including infra-red)	45.4	106.8	136.8	461.6	484.9	308.8	292.2			
Receivers, radio communications (except amateur and Citizens Radio)	1,085.6	1,290.3	1,390.6	1,678.1	1,952.7	2,001.4	1,764.2	1,761.7	1,914.4	2,050
Transmitters and RF power amplifiers										
Carrier current communications systems and equipment n.e.c.	113.4	161.2	220.0	116.8	136.5	140.4	127.1	182.7	216.4	245
Space satellite communications systems	1,094.6	1,614.4	1,759.7	2,277.4	2,281.4	2,391.7	2,224.3	2,386.7	2,491.1	2,580
Telemetering systems and equipment	183.9	192.1	304.0	246.1	358.1	376.8	378.7	323.9	222.2	225
Mobile radio systems	214.1	217.6	213.9	283.2	228.6	361.0	630.2	747.1	1,038.4	1,350
Mobile base stations	231.8	216.0	187.7	199.3	217.1	354.2	326.2	472.9	919.3	1,250
Mobile vehicular transmitters/receivers	396.5	426.9	426.9	612.3	678.8	432.2	706.9	760.4	899.4	1,025
Portable receivers, transceivers and transmitter-receivers	466.9	510.2	535.5	716.5	648.4	778.6	926.2	1,420.2	1,573.0	1,715
Amateur radio communications equipment	71.3	9.0	7.3	7.3	9.5	9.2	na	21.9	22.0	20
Citizens Radio communications equipment	15.2	3.5								
Checkout, monitoring, evaluation and other electronic support equipment for communications systems	136.2	182.6	241.7	251.8	241.4	277.1	316.3	304.0	214.7	200
Communications antennae, below 890 megahertz	122.9	140.6	129.1	107.8	110.6	134.1	159.8	180.6	179.2	180
Microwave antenna systems	96.7	147.6	145.8	161.7	168.3	209.3	254.6	278.4	305.7	330
Other communications equipment	1,233.9	1,361.5	1,567.6	1,783.6	2,561.7	2,713.2	2,853.7	2,655.1	3,105.5	3,400
TOTAL	5,583.4	6,668.6	7,542.1	9,157.5	10,606.5	11,124.6	11,394.7	12,212.7	13,879.5	15,400
Broadcast, Studio and Related Electronic Equipment										
Audio equipment	149.0	174.0	186.5	219.3	209.8	209.4	276.6	316.8	327.5	335
Video equipment	389.0	480.9	461.2	496.2	509.3	527.0	501.3	595.5	610.5	625
Transmitters, RF power amplifiers and related equipment	149.5	127.1	111.4	107.3	135.1	122.2	124.4	128.1	104.4	105
Studio transmitter links (STL) and remote pickup equipment	23.9	18.6	41.5	7.9	18.8	17.4	16.6	43.3	37.8	35
Cable TV equipment	410.1	459.4	452.5	410.4	375.2	382.7	327.0	423.5	495.8	550
Closed circuit TV equipment	118.7	123.3	99.2	109.3	125.2	141.1	95.8	135.3	129.5	130
Broadcasting transmitting antennae and community antennae systems	105.9	74.6	49.4	38.2	94.7	60.3	50.0	45.2	42.4	40
Other communications equipment (broadcast, studio, theater and commercial sound equipment)	100.5	85.9	62.6	87.2	93.8	93.4	216.7	116.6	100.7	80
TOTAL	1,446.6	1,543.8	1,464.0	1,475.8	1,561.9	1,553.5	1,608.4	1,804.3	1,848.6	1,900
Intercommunications Systems, Alarm Systems and Traffic Control Equipment										
Intercommunication equipment electronically amplified (excludes intercommunication equipment designed primarily for use in telephone and telegraph networks)	324.6	324.6	176.1	212.6	172.6	195.2	282.8	392.6	397.4	400
Alarm systems (includes intrusion and fire detection equipment)	761.1	833.5	879.6	1,045.2	1,114.3	1,028.2	1,235.0	1,164.7	1,275.6	1,300
Traffic control equipment (vehicular and pedestrian, railway signals and attachments)	500.5	413.1	481.0	474.2	455.7	446.2	426.4	387.0	464.1	475
TOTAL	1,586.2	1,571.5	1,536.7	1,732.0	1,742.6	1,669.6	1,944.2	1,944.3	2,137.1	2,175

See footnotes at end of table

Factory Shipments of Communications Equipment ($ Million); United States, 1981-1990

TABLE 2-3 (Continued)

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Search and Detection, Navigation and Guidance Systems and Equipment										
Light reconnaissance and surveillance systems and equipment including checkout, monitoring, evaluations and other support equipment	1,075.5	1,641.1	1,666.3	2,225.6	2,410.5	2,824.7	2,739.9	2,865.9	2,608.3	2,635
IFF equipment	186.9	94.0	151.5	174.0	156.3	155.5	226.8	287.7	289.1	300
Proximity Fuses	118.9	154.4	209.9	259.6	196.9	281.3	234.6	300.6	359.9	400
Radar systems and equipment (search, detection, acquisition)	1,900.0	2,441.5	3,344.3	3,698.8	4,321.0	4,625.3	3,751.4	3,658.8	3,646.0	3,800
Tracking radar	1,701.5	1,779.1	2,088.4	1,820.5	2,207.5	2,452.2	2,900.4	2,915.6	3,247.1	3,400
Instrumentation radar	92.5	101.4	74.1	200.6	226.3	185.4	201.9	221.4	147.0	150
Checkout, monitoring, evaluation and other support equipment for radar systems	226.5	267.0	329.2	435.0	474.4	445.9	479.9	453.6	331.0	335
Sonar search, detection and tracking systems and equipment	978.1	1,155.5	1,374.2	1,620.0	1,885.3	1,933.8	1,835.0	1,735.6	1,700.5	1,760
Checkout, monitoring, evaluation, etc. for sonar	256.4	259.7	287.8	250.6	333.9	402.0	310.9	251.7	199.6	200
Specialized command and control data processing and display equipment sold separately from complete systems	314.8	399.5	536.7	921.4	977.0	1,127.9	1,505.9	1,519.0	1,248.0	1,260
Meteorological electronics equipment and radio astronomy equipment	44.7	67.6	78.7	85.7	127.5	213.2	292.5	361.6	260.2	265
Geophysical electronic equipment	461.5	351.6	228.5	316.4	311.1	204.2	222.1	181.6	199.9	210
Search, detection, identification, and tracking systems, n.e.c.	893.2	1,047.8	1,189.4	1,510.0	1,961.1	1,953.4	1,964.0	1,784.0	1,810.3	1,880
Missiles-borne and space-vehicle-borne equipment	1,582.5	1,867.2	1,855.9	2,204.9	2,731.9	3,410.3	4,169.4	4,452.9	4,311.9	4,440
Non-missile and space vehicle guidance	325.3	394.6	420.2	480.2	508.3	536.5	540.7	482.7	485.3	505
Checkout, launching and other missile and space vehicle support systems	249.0	392.5	490.1	468.5	765.1	705.6	654.5	629.4	481.7	485
Counter measures equipment (includes jamming and underwater equipment)	1,003.6	1,283.5	1,595.8	2,036.5	2,682.1	3,089.6	3,527.1	3,314.7	2,613.6	2,800
Specialized electronic and communication intelligence equipment	1,051.0	1,345.9	1,349.1	1,370.2	1,809.5	1,895.4	2,049.1	2,271.7	2,208.8	2,275
Navigation systems and equipment for aircraft, ship, and ground navigation (autopilots, beacons, collision warning devices, direction finders, SHORAN, TACAN, VOR, VORTAC equipment, etc.)	2,578.4	2,689.1	2,711.6	2,744.1	2,971.3	3,478.9	3,819.5	4,000.5	4,634.3	4,800
TOTAL	15,040.3	17,733.0	19,981.7	22,822.6	27,057.0	29,921.1	31,425.6	31,689.0	30,982.5	31,900

r-Revised
e-Estimated by EIA Marketing Services Department
na-Not Available
SOURCE: U.S. Department of Commerce

networks. The newest machines also offer Integrated Services Digital Network (ISDN) compatibility. (See the ISDN section of this chapter.)

NATA predicts renewed growth for the PBX market as older systems are replaced and ISDN increases demand. Although the market has grown slowly since a buying spree in 1984 and 1985, the trade association predicts system sales to grow from $2.9 billion (29,000 units) in 1989 to $3.4 billion (32,000 units) by 1995.

Centrex demand, which had levelled off in the 1970s and early 1980s, also has started a revival. After the divestiture of AT&T in 1984, the RBOCs started to actively market Centrex services with enhanced digital features, including ISDN compatibility. As a result, the market is expected to grow 10.9% annually from 1989 through 1996, according to Market Intelligence Research Corporation. Total revenue for 1990 is expected to be $2.6 billion compared to 1989's total of $2.3 billion.

The market for key systems, meanwhile, is expected to grow at a much slower pace. NATA forecasts 5.8 million stations, valued at $1.3 billion, to be sold in 1995. In 1989, the total was 4.3 million stations ($995 million value), only a

Factory Shipments of Telephone and Telegraph Equipment ($ Million); United States, 1981-1990

TABLE 2-4

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Private Branch Exchange Equipment	1,088.0	1,047.8	1,050.1	1,603.7	1,720.8	855.9	1,412.3	1,011.2	845.9	890
Central Office Switching Equipment	1,764.1	1,958.9	2,218.5	2,856.9	4,332.8	4,472.3	4,550.4	4,925.4	4,699.8	4,800
Other Switching and Switchboard Equipment	1,510.9	1,441.2	1,362.1	1,410.6	1,660.7	1,851.9	1,404.5	1,463.1	1,521.3	1,560
Carrier Line Equipment	1,602.1	1,563.4	1,488.5	1,917.3	2,329.5	2,833.0	3,720.3	4,342.5	3,492.6	3,575
Telephone Sets	1,039.9	1,064.9	831.2	846.7	1,218.6	790.6	299.9	346.0	355.7	375
Teleprinters	311.2	334.0	387.2	294.1	270.8	361.2	na	na	na	na
Modems	633.4	655.6	791.2	848.3	829.5	1,229.2	1,291.4	1,246.5	1,124.5	1,175
Voice Frequency Equipment	257.8	213.5	227.9	301.7	328.3	243.0	175.0	155.5	120.8	110
Answering Devices	na	na	na	na	na	na	96.1	36.7	33.9	40
Key Systems	na	na	na	na	na	na	622.0	422.3	344.0	360
Facsimile Equipment	138.6	185.5	151.7	100.2	64.4	59.5	108.6	202.0	195.6	210
Other Telephone and Telegraph Equipment and Parts	3,656.7	3,148.4	3,065.9	4,161.4	3,371.5	2,857.5	2,314.8	1,904.0	2,023.9	2,105
TOTAL	12,002.7r	11,613.2r	11,594.3r	14,340.9r	16,126.9r	15,554.1r	15,995.3r	16,055.2	14,758.0	15,200

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

slight increase from the 1985 total of 4.2 million stations, valued at $995 million. NATA expects key systems using Centrex—most likely 1 to 24 lines—to grow the fastest.

Call Processing Equipment

One of the largest call processing equipment growth areas in the past few years has been call or voice processing equipment, which can be used in conjunction with PBX or as a stand-alone system. A $483 million market in 1986, the market reached $1.59 billion by 1989. Since 1984, the market has experienced a compound annual growth rate of 170%.

The call processing equipment market can be divided into voice mail or messaging, automatic call distributors, and automatic dialers (used mainly in telemarketing). The fastest growing element is voice mail: Venture Development expects an annual growth rate of 30% with sales reaching $2.2 billion in 1992. Digital-based voice mail can provide the ability to dictate a message immediately after listening to one; selectively choose or delete messages; and schedule messages to be delivered at different times.

According to an industry observer in *The New York Times*, "Sixty percent of telephone calls (at his company) did not require two-way communications," only the relaying of information. Although critics dislike the impersonal aspect of talking to a machine, the benefit of eliminating "telephone tag" appears to be ruling the market.

Voice mail is making news now, but voice response systems are expected to grow even faster in the years ahead. NATA forecasts a $1.4 billion market by 1995 as new applications develop and consumer acceptance rises. A voice response system usually is customized to the needs of the individual customer and offers voice messages combined with other features such as automatic attendants and database management equipment. The result is either an interactive or noninteractive system that gives a caller several options from which to choose, accesses a database based on the caller's selection, and provides verbal information from the database to the caller. An interactive system could allow bank transactions, for example, while a noninteractive system merely would provide information to the caller.

Facsimile

Facsimile devices are grouped into categories by speed of transmission. Group 1 & 2 standards, established in the 1960s, describe very slow transmission speeds by today's Group 3 standards. (Group 1 machines require six minutes per page compared to one minute or less per page for Group 3.) Group

U.S. PBX Market, Estimated Manufacturer's Shipments* (Thousands of Units) 1981-1990

TABLE 2-5

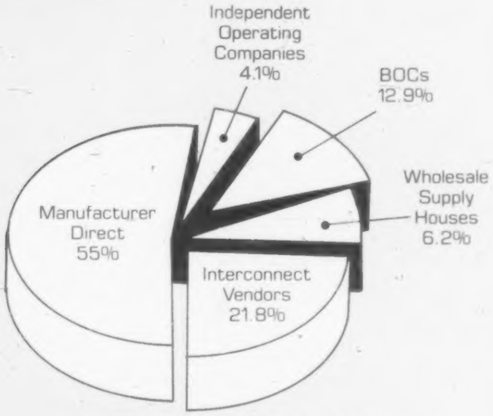
YEAR	UNITS (THOUSANDS)
1981	2,865
1982	3,080
1983	3,270
1984	3,790
1985	4,115
1986	4,140
1987	4,175
1988	4,319
1989r	4,201
1990e	4,245

*Includes shipments at the original equipment manufacturers' level intended for the U.S. market, including imports.
r-Revised.
e-Estimated.
SOURCE: North American Telecommunications Association.

3 products created the mass market by having a high-enough performance level for speed and resolution, without degrading reliability or adding an unreasonable cost burden. The Group 3 standard has been adopted on an international basis, allowing for mass production and the associated economies of scale that have contributed to lower costs. At present, Group 4 machines, which transmit one page in only a few seconds, are geared for wideband communication lines and high-volume use by large companies. Their growth will be enhanced by the Integrated Services Digital Network (ISDN) that is expected to become functional by the mid- to late-90s, as well as the expansion of the user base via price reductions.

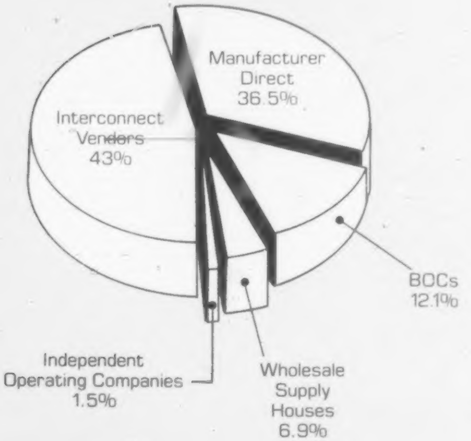
PBX Shipments by Manufacturers' Distribution Channel: 1989

FIGURE 2-8



Total Shipments: 4.2 Million Lines

Key & Hybrid Shipments By Manufacturers' Distribution Channel: 1989



Total Shipments: 4.3 Million Stations

SOURCE: NATA.

Lower costs combined with better quality transmissions have made the fax market a prime growth area. NATA expects the market to more than double by 1995, reaching 6.6 million terminals at a value of $6.5 billion, compared to the 1989 amount of 1.9 million terminals valued at $2.9 billion. Although home office and small business automation should be one of the largest growth areas (see the Consumer Electronics chapter), manufacturing companies now are one of the largest users of the equipment. NATA reports approximately 97% of manufacturing facilities used fax transmission in 1989, closely followed by business services at 96%.

Despite their progress down the cost curve, fax prices have not yet reached the flash point for the average consumer. Also, their true functionality depends on equipment at the sender's and receiver's locations. A third drawback, albeit a minor one, is that the copies from popularly-priced units are on thermal paper and their printed impressions fade over time. Another factor that detracts from stand-alone fax machine growth is the alternative choice for fax capability in computers. These fax boards turn PC's into "partial" fax machines, but require a scanner for input, along with the printers, monitors, software and hard discs likely to be in place by the sophisticated user of the fax board.

Offsetting these drawbacks are the facsimile's capabilities of going beyond typed or printed letters and numbers—by transmitting graphics and "exact" copies of documents and photos with acceptable speed and quality. A growing demand for portable/mobile hard copy is stimulating the use of fax machines in conjunction with cellular phones. At the same time, the number of small business service firms offering photocopying, mail, and fax facilities also has been growing. As consumers use such services more frequently, they will become motivated to have their own equipment at home. Although this trend may dampen fax growth in small businesses, it most certainly will not eliminate the service. Like so many other examples in electronic products, today's threat turns out to be tomorrow's coexistence.

Modems

Once all digital networks become commonplace, modems, which permit computers to exchange data over telephone lines, will become obsolete. For now, however, sales of modems continue to increase and most likely will do so for at least ten more years.

The Computer and Business Equipment Manufacturers Association (CBEMA) reports 1989 U.S. shipments of modems at 2.5 million units, projected to grow 9.6% in 1990 to 2.74 million units. By the year 2000, the association expects unit shipments to reach 4.9 million units. At the same time, however, annual revenue is expected to drop at an average annual rate of 3.8% as the average unit price falls.

SATELLITE COMMUNICATIONS

Satellite communications consists of a space segment, essentially the communications satellite, and a ground segment, made up of earth stations and tracking, telemetry and control (TT&C) equipment. The communications satellite basically is a sun-powered microwave radio receiver and broadcast unit placed in orbit to receive carefully aimed radio signals from

U.S. PBX-Centrex Market, Installed Base Development* (Thousands of Units); 1986-1990 **TABLE 2-6**

	1986	1987	1988	1989	1990
TOTAL PBX	24,379	25,320	25,897	25,145	25,200
TOTAL CENTREX	7,355	7,525	8,100	8,223^{r}	8,616
TOTAL PBX-CENTREX	31,734	32,845	33,997	33,368^{r}	33,816

*Installed base refers to the cumulative total of instruments (telephone handsets or equipped lines) in use at the end of each calendar year.
r-Revised.
SOURCE: North American Telecommunications Association.

an earth station transmitter and transmit them back to earth. On the ground, a receiving dish collects and concentrates the signals, then amplifies them to the power levels required by telephone, television, or other end equipment. Communications satellites are placed in a stationary orbit over the equator; those located from 83 degrees to 135 degrees west longitude cover the western hemisphere.

In 1990, the satellite industry went through a period of renewed growth, following several years of setbacks from satellite launch failures. According to *U.S. Industrial Outlook '91*, production of complete space communications satellite systems increased around 5% to more than $2.7 billion in 1990. The space segment accounted for about $1 billion of domestic satellite systems as U.S. manufacturers shipped nine satellites for export. Only eight satellites have been scheduled for delivery in 1991; however, 51 satellites are on order worldwide for 1991 through 1993.

As with the space market, the ground segment of satellite communications offers myriad opportunities for growth. After several years of dominance by broadcasting and cable applications, the earth station sector is turning to new market areas such as Very Small Aperture Terminal (VSAT) networks, Television Receive Only (TVRO), Direct Broadcast Satellites (DBS), and Mobil Satellite Systems (MSS).

U.S. Key Telephone Market, Estimated Manufacturer's Shipments* (Thousands of Units and $ Millions); 1981-1990 **TABLE 2-7**

YEAR	UNITS (THOUSANDS)	DOLLARS (MILLIONS)
1981	2,900	870
1982	3,050	915
1983	3,350	921
1984	4,240	1,039
1985	4,150	955
1986	4,199	957
1987	4,259	960
1988	4,260	965
1989^{r}	4,275	995
1990^{e}	4,395	1,050

*Includes shipments at the original equipment manufacturers' level intended for the U.S. market, including imports.
r-Revised.
SOURCE: North American Telecommunications Association.

VSAT networks, reports *Satellite Retailer*, connect various locations through small antennas on terminals aimed at the same communications satellite. The networks completely bypass existing transmission systems; all communications are through the VSAT network controlled by a larger "hub terminal." The advantages of VSAT networks, according to *Satellite Retailer*, include "low cost per location, full digital compatibility, excellent reliability, flexibility, fast reconfiguration, and easy expansion." *U.S. Industrial Outlook '91* expects domestic equipment revenues for VSAT networks to reach $1.7 billion, with about 300,000 units installed, by 1995. Analysts predict similar growth in Europe as regulations change to encourage growth in the telecommunications arena.

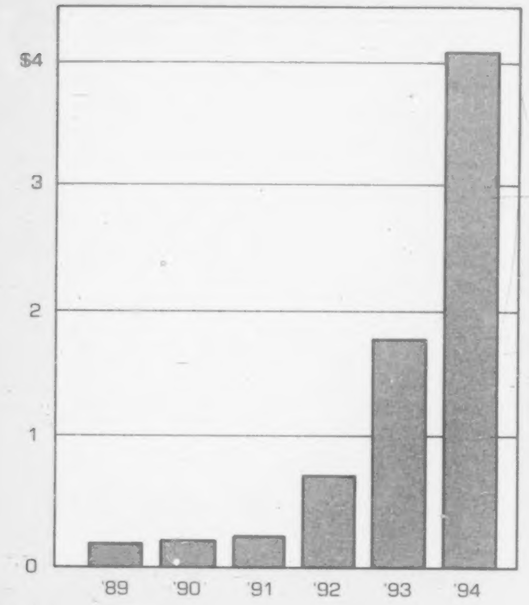
Mobile satellite services also offer tremendous growth opportunities for the next five years. Gartner Group Inc. forecasts a 150% compound annual growth rate from 1990 to 1995, which means the number of terminals would increase from 20,000 to 2 million. MSS are characterized by small, easily-mounted terminals on land, sea, or air vehicles. The systems are ideal for field communications and for navigation, paging, and location information. As an example, the trucking industry increasingly is using MSS to track truck locations and communicate with drivers.

Meanwhile, TVROs continue to compete with cable television services. *U.S. Industrial Outlook '91* reports a market value of just under $400 million in 1990, with growth in unit sales expected to increase 10% to 15% annually through 1993. If Direct Broadcast Satellite (DBS) efforts prove successful, the TVRO market could grow even further. Currently, however, the future of DBS is uncertain. Although widely available in Japan and parts of Europe, it is still in planning stages in the U.S., with the first highpower DBS system scheduled for launch in 1993.

MICROWAVE TRANSMISSION

Microwave transmission, a term used to describe the use of frequencies of 1GHz or more, is an economical means of mov-

Mobile Satellite Systems Worldwide Revenue ($ Billions) **FIGURE 2-C**



SOURCE: Gartner Group

ing large amounts of voice, video, and data signals from point to point, either terrestrially or via satellite. First used commercially in the United States in 1945, microwave transmission now provides a wide range of communications services, including television, radio, telephone, telegraph, facsimile, and data transmission.

The traditional use of microwave systems in long-haul paths of up to 40 miles gradually is being discarded in favor of short-haul, high frequency systems in the 18 GHz or 23 GHz range. The short-haul microwave systems offer an advantage over fiber optic and satellite since they can be installed inexpensively and easily. Recently, microwave systems have found a niche in both high-frequency urban markets and less accessible rural markets. *Business Communications Review* reports that microwave systems also are becoming a popular back-up technology for existing telephone systems when natural disasters or other problems temporarily disrupt services.

According to *U.S. Industrial Outlook '91*, domestic shipments of complete microwave systems were valued at $870 million in 1990, up 2% from 1989 and 25% from 1988. Analysts predict slow growth in the 2-3% range to continue through the next few years.

Most of the growth will be in short-haul digital operations. In fact, almost all new systems now being installed are digital rather than analog. The newer digital microwave transmission systems (DMTX) reduce equipment and installation costs while increasing system effectiveness, according to Telecommunications. DMTX systems take advantage of already installed digital switches and more readily transmit digital signals.

Applications for microwave systems include the traditional common carrier sector, which makes up about 60% of the installed base; private microwave systems, representing about 15% of the market; government agencies, and broadcasting systems. Cellular phone networks use microwave systems to connect transmission "cells" and cable television companies increasingly are using Cable Antenna Relay Services (CARS) to bridge gaps between cable systems. The FCC reports 2,287 CARS systems licenses issued in 1990 and expects to see 10% annual growth in the number of licenses issued in the next few years. Meanwhile, another microwave application, the fledgling "wireless cable" industry, which relies solely on microwave transmissions to broadcast programs, is struggling to compete with cable TV.

Another trend in the microwave industry is that of companies bypassing traditional public telephone networks via microwave transmission. As reported in *High Technology*, several companies sell microwave radio equipment that allows a customer to establish a direct digital link to an interchange carrier's point of presence. Although such a microwave link costs about $25,000, the payback period may be as short as two years. Microwave is a common option for facility bypass, because no companies have the right-of-way to install terrestrial cables. There are drawbacks, however, *High Technology* reports. Microwave transmission needs a clear "line of sight" between end-points, and rain and snow tend to interfere with transmissions at frequencies higher than 11 GHz.

CELLULAR RADIO

Cellular phones, once a status symbol more than a communications medium, finally have entered mainstream America. By 1994, more than 10 million units could be in use, up from 2.7 million units in 1989, according to Venture Development Corporation (VDC), which forecasts 30% annual growth for the industry from 1989 to 1994. Other analysts also expect huge growth. Market Intelligence Research Corporation (MIRC) predicts the development of a digital network will give more people access to cellular phones, while, at the same time, lower prices will appeal to the consumer market and to those in sales and marketing, management, and service industries. MIRC also sees the cellular market interacting with the pager and voice mail markets. Callers can contact a cellular subscriber by leaving a message in a voice mailbox, which in turn alerts the called party via a pager.

Cellular radio systems operate by sending radio signals to nearby transmitting stations. The limited frequencies available on radio bands are divided into cells, which are served by transceivers in each market area. When one cell becomes busy, it is divided into smaller cells using less transmission power. Cells generally serve a radius of 8 to 12 miles and can be split three times, with the minimum radius being 1 to 1.5 miles. Approximately 3,000 customers per cell can be serviced simultaneously without excessive service delays.

A cellular mobile radio system consists of a mobile radiotelephone, transmitter and antenna, a small base station within each of the cells into which a region is divided, and a main switch controller called the Mobile Telephone Switching Office. The FCC has allocated licenses for two cellular telephone systems in each city—one wireline to be operated by an established telephone company and one non-wireline to be operated by independent companies.

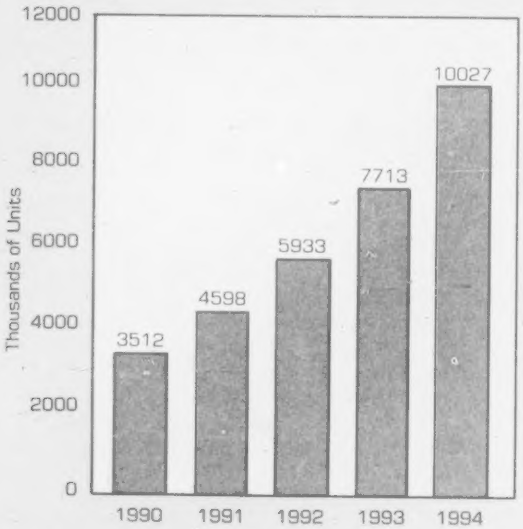
Quality of service is maintained as a user drives from one part of a city to another, even from one cell to another. As the user enters a new cell, a central microprocessor and specialized radio equipment automatically adjusts to the new cellular system without interruption. With the increasing number of subscribers, however, cellular systems are getting overcrowded. Industry experts hope conversion from analog to digital technology will relieve congestion in the near future.

LAND MOBILE RADIO

With the explosion of the communications industry in recent years, two-way land mobile radio services have stood out as a sector of the industry which has witnessed dramatic growth. Virtually every type of public safety agency, business, utility, transportation activity, and state and local government has come to rely on land mobile radio as an indispensable part of its operation.

Land mobile radio is more than just a means of communication—it is a vital management tool. By utilizing it properly, a manager is able to assign resources and manpower to those locations or activities where they are needed the most or where expediency and timeliness is an important factor. To a police department, land mobile communications means responding quickly to a citizen's call for assistance through the officer or patrol car nearest the scene. To a contractor, it means routing heavy equipment and work crews to job sites in a timely manner. And to a plumber or other service provider, it means efficient and quick assignment of crew to correct locations and the ability to give instructions on the scene.

U.S. Installed Base of Cellular Telephones, 1990-1994 **FIGURE 2-D**



SOURCE: Venture Development Corp.

Market statistics for mobile radio appear in Table 2-3. The greatest opportunities for equipment sales will be in the realm of 800 MHz hardware to private services. Conventional radiotelephone has little future unless other uses can be found for the limited number of channels authorized.

There are several reasons cited for the rise in both the use and sale of private radio services. The addition of 600 two-way channel pairs by the Federal Communications Commission (FCC) has increased the capacity of the 800 MHz band for private radio services by more than 35%. Because most channel pairs can be used in trunked systems, the effect of the addition can be increased even further. In addition, the simple forms of digital transmission of messages to supplement voice contacts further enhances communication capacity. While the addition of 600 channels to the 800 MHz band will help private radio services, these additional channels will erode carrier conventional mobile radiotelephony. This, combined with the FCC's plan to extend the availability of private radio telephone interconnection to the lower UHF and VHF frequencies, will bring about the demise of carrier mobile radiotelephones. Common carrier radiotelephone hardware already is giving way to cellular phones.

CABLE TELEVISION

Cable television, also known as Community Antenna Television (CATV), began service in 1948 to bring distant television signals to isolated communities where reception from stations was poor or nonexistent. Later, cable service was introduced in suburban areas and a few cities, where it added the programs of one or two distant stations to those available from the local stations. The higher cost of installing cable in large cities, coupled with the greater variety of local TV programs readily available, kept cable systems out of many urban markets.

Domestic communications satellites revolutionized the cable TV industry by allowing low cost distribution of programming to independent cable systems throughout the country. In the 1970s, cable services expanded from the early five to twelve channel systems to 30 to 35 channel offerings. Cable program services such as Home Box Office (HBO), the Movie Channel, and countless others were established to provide premium programming. In the 1980s the industry grew rapidly from only one profitable cable service in 1983 (TBS, the Atlanta-based superstation), to 12 profitable services out of the 15 largest advertiser-supported programming services, according to the Cable Television Advertising Bureau (CTAB). "Three of them—TBS, Cable News Network (CNN), and ESPN—each earned more than the CBS and ABC television networks combined," cited CTAB.

By 1990, total revenues for cable television reached $18.75 billion, according to estimates from Paul Kagan Associates, $16.2 billion of which came from subscriber services and $2.55 billion from advertising.

The spectacular growth of the last five years will not continue long, however. Both the *Veronis, Shuler & Associates Communications Industry Report* and *U.S. Industrial Outlook '91* expect revenue growth in the 5-8% range in the early 1990s. Regulatory scrutiny of the industry coupled with a slower penetration rate is listed as the primary reason for slowed growth. Even so, the outlook is far from negative for

Estimated Size of Cable Television Industry; United States, December 1990 TABLE 2-8

Number of Cable TV Systems	9,621
Basic Cable Subscribers (Homes served)	54.9 Million
Penetration:	
Homes served as percent of homes passed by cable	65%
Homes served as percent of U.S. TV households	59%
Homes passed by cable	84.6 Million

Source: National Cable Television Associaiton.

cable TV. Advertising revenues are expected to increase, as are the number of households subscribing to cable, from 50.7 million in 1989 to 54.9 million in 1990.

TELETEXT/VIDEOTEX

Early efforts in the U.S. to achieve success in the "information service" industry via teletext (data transmitted simultaneously with TV signals and decoded at the local TV or terminal) and videotex (users dial into a database from a terminal or computer to receive a video display) met with the same frustration that many new products or services experience — insufficient customer awareness. Although people within the industry saw its promise, pointing to successful European examples, the average U.S. consumer and business had little knowledge of its benefits. Large companies pooled resources in joint ventures to provide services but, to this day, the next wave of user (beyond the computer-literate population and other special niche areas) has not yet crested. The awareness factor, however, is gradually building, as shoppers find a wider variety of automated information kiosks in malls and grocery stores and travelers become more acquainted with electronic billboards and hotel-room check-out systems.

Another factor that will impact the electronic information service industry growth is standardization. Such standardized approaches as the integrated services digital network (ISDN) could help speed the development of a simplified terminal. Additionally, providers such as telephone companies (offering options such as smart phones with call-tracing and online directories), financial organizations (banking transactions), retailing (home shopping), mass media (news, weather, sports) and reference resources (databanks), could benefit from standardization.

DATA COMMUNICATIONS NETWORKS

One area that epitomizes the global nature of the electronics industry is that of network equipment and services. Networks rapidly are covering the globe, connecting entire industries as well as tiny divisions within a single company. The computer and communications industries have become mutual participants in serving the world's appetite for rapid and effective use of information. As efforts toward standardization take place, the race toward digitalization, and the wide variety of products available such as telephones, data terminals, fax, telex, videotex and PCs, will help the world move towards a compatible, retrofittable environment.

As businesses and information users demand interconnectivity, the network market as a whole is growing rapidly. Frost & Sullivan expects the entire U.S. market to reach approximately $18 billion in 1993, compared to $5.7 billion in 1988. Another research firm, The Freedonia Group, projects a 33% annual increase in U.S. sales of local and wide area networking products and services through 1993, reaching a total of $14.7 billion. Networks generally can be defined based on the size of the network configuration as outlined in the following sections.

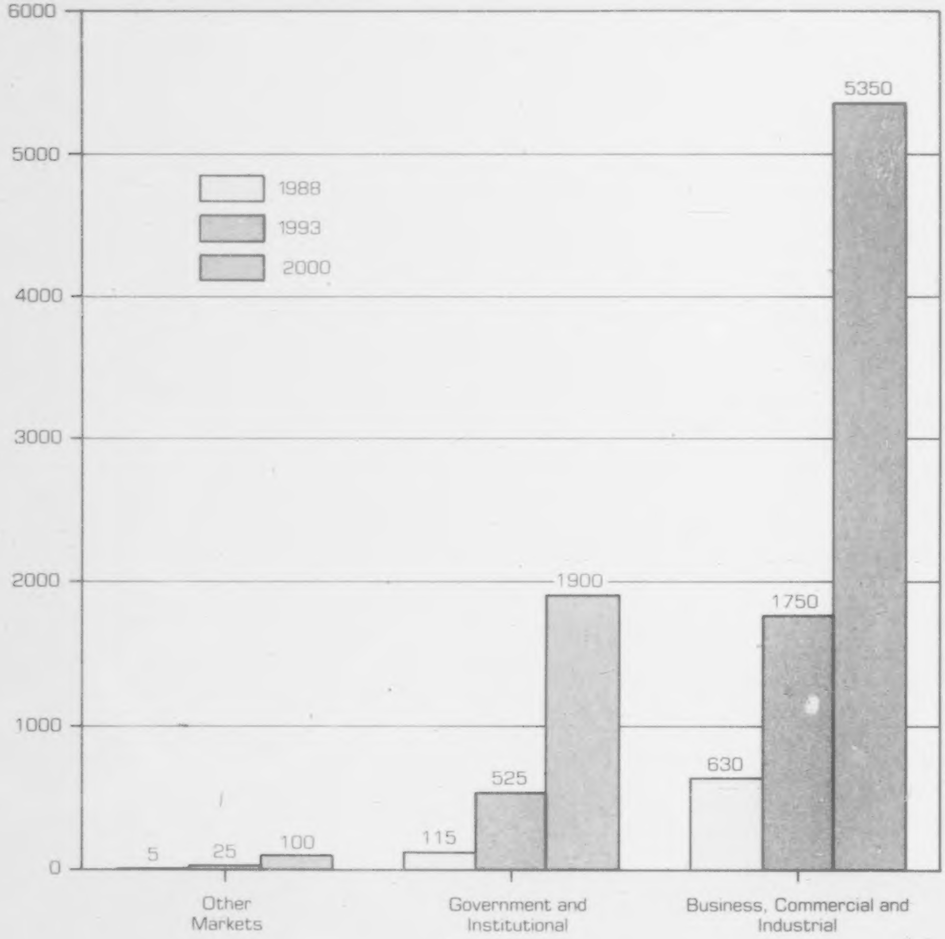
Growth of Cable Television Industry; United States, 1981-1990 TABLE 2-9

YEAR	TELEVISION HOMES	CATV SYSTEMS	BASIC CABLE SUBSCRIBERS	PERCENT OF CABLE PENETRATION OF TV HOMES
1981	77,251,800	4,375	18,300,000	23.7
1982	81,496,500	4,825	21,000,000	25.8
1983	83,462,600	5,600	25,000,000	30.0
1984	83,971,800	6,200	30,000,000	35.7
1985	86,400,000	6,668	37,900,000	43.9
1986	87,476,100	7,737	40,640,600	46.5
1987	88,420,260	7,836	43,529,660	49.2
1988	89,120,260	8,413	46,662,200	52.4
1989	91,192,205	9,010	50,699,000	55.6
1990	93,085,870	9,621	54,871,330	59.0

SOURCE: National Cable Television Association.

U.S. Voice/Data Communications Equipment and Systems Sales by Market ($ Millions)

FIGURE 2-E



SOURCE: The Freedonia Group, Inc.

Local Area Networks

Local area networks (LANs) cover a relatively small area, ranging from several feet to a mile, and usually are within one organization or structure. During the next three years, LAN sales will continue to expand rapidly. Electronics Trend Publications forecasts an average growth rate of 22% in the worldwide LAN market from 1988 through 1993, reaching $8.1 billion in 1993. The number of PCs and facsimile devices connected to LANs naturally will be growing in conjunction with the number of LANs sold. By 1993, 25.9 million PCs will be connected to LANs worldwide, showing a 71% annual growth rate from 1990, according to Workgroup Technology. The number of fax machines connected to LANs is expected to grow even more dramatically. BIS Corp International expects a 139.7% average growth rate from 1989 to 1993, with 198,000 faxes connected to LANs by that time.

Currently, most LANs are configured using the Ethernet standard; however, as networks become overloaded with traffic, the need for high speed and clarity are turning users to two other standards, Token Ring and FDDI. Although most LANs shipped in 1990 still used the Ethernet interface, sales of Token Ring interface cards surpassed those of Ethernet cards in 1990 and will continue to do so in coming years, according to *Computer Reseller News*. Meanwhile, sales of FDDI (Fiber Distributed-Data Interface) cards also are gaining ground. FDDI is a fairly new fiber-optic based technology that operates at extremely high speeds— 100 megabits per second (mbps) compared to 10 mbps for Ethernet and 4 or 16 mbps for Token Ring. *Computer Reseller News* reports a possible worldwide market of $163.7 million for FDDI interface cards by 1994.

Wide Area Networks

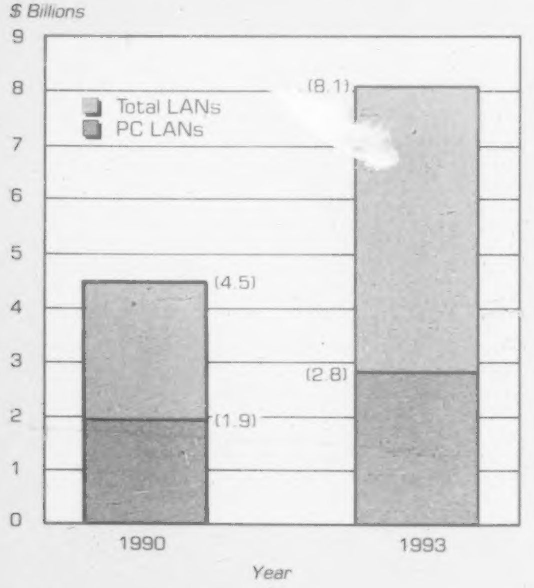
Wide area networks (WANs) transmit via cable, microwave, satellite equipment, or combinations of the three, over a large geographic area up to hundreds of miles wide. WANs can be private networks or can use facilities of local and long distance telephone companies or other public networks. Frost & Sullivan estimates a $6.5 billion U.S. market for WANs in 1995, compared to $4 billion in 1989.

Metropolitan Area Networks

Metropolitan area networks (MANs), sometimes called bypass carriers, offer businesses an alternative route to connect to long distance services. MANs compete with local telephone carriers through "self-healing rings," according to *Communications Week International*, which actually are full-circle fiber loops that offer protection against network breakdown plus fast, high-capacity, digital transmission.

As companies call for more backup protection, MANs are beginning to prosper across the U.S. Kessler Marketing Intelligence expects 29 MANs to be operating in 18 U.S. cities by the end of 1991. Annual revenue for the companies is increasing dramatically every year and new players are expected to begin competing in what MIRC says should be a $1.2 billion market by 1996.

Worldwide LAN Market, 1990 vs. 1993 FIGURE 2-F



SOURCE: Electronic Trend Publications

INTEGRATED SERVICES DIGITAL NETWORK

ISDN is the future—in some cases, the present—of networking. The International Telecommunications Union defines ISDN as: "a network evolved from the telephony integrated digital network that provides end-to-end connectivity to support a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multipurpose customer interfaces." More simply, ISDN refers to standardized all-digital networks that process voice, data, and video communication through one system. The objective is a high-speed, cost-effective, globally compatible network.

The evolution of ISDN has been slow, starting in the early to mid-80s and still continuing today. Although RBOC-sponsored ISDN trials took place beginning in 1986 and most of the network standards now have been established, the standards for terminal equipment still are being worked out. Currently, the seven Regional Bell Operating Companies have approximately 200 ISDN customers and at least 90,000 ISDN lines. However, full implementation of ISDN remains for the future. Industry analysts do not expect wide use until at least 1992; less optimistic analysts quote 1997 as the first year of widespread availability.

FIBER OPTICS

Fiber optic systems use small lightweight cables, made from glass or plastic, to transmit electronic signals between different locations. The cables are characterized by their ability to transmit huge quantities of data, voice, or video. Indeed, fiber optic cable can carry as much information as 21½-inch copper cables. The fiber optic medium has an added attraction of not being susceptible to electric, electromagnetic, or radio frequency interference, thus providing enhanced signal security, important to both government and business users.

The advantages of fiber optic systems, combined with a recent trend towards lower prices, have made the industry ripe for growth. Market Intelligence Research Corporation (MIRC) expects the market for local-area fiber networks alone to grow from $55 million in 1986 to about $1 billion in 1996. Fiber-based metropolitan area networks (MANs) are expected to increase even more, from about $30 million in 1986 to $1.2 billion by 1996.

The U.S. market grew to $1.4 billion in 1990, including optical fiber ($325 million), systems and equipment ($500 million), fiber optic cable ($650 million), and fiber optic test equipment ($13 million) according to the U.S. Department of Commerce's *U.S. Industrial Outlook '91*. Analysts expect even more growth throughout the decade. One research firm, Leading Edge, forecasts a $4 billion-plus market by the end of the decade.

A huge boost for fiber optics is expected from the forthcoming FDDI standard (Fiber Distributed Digital Interface), growing from an installed base of only 200 transceivers in 1989 to 22,000 the next year, and a tenfold increase to 200,000 by 1992, according to Kessler Marketing Intelligence. The burgeoning demand for ever-increasing masses of electronic signals—whether they be data, voice, video, or all of the above, will foster the growth of new products and services that will benefit all facets of our society. In the business, government, and educational communities, the various networks are heading toward further interconnection. LANs, VANs, WANs, and more recently, MANs, all exemplify this connectability trend. The LAN market is expected to exceed $5.75 billion and utilize more than $800.000 fiber optic LANs by 1992, according to Dataquest.

One of the rapidly expanding areas in fiber optic technology is home fiber networks. As early as 1988, Heathrow, a planned city in Florida, used fiber optic cable to link all its buildings to an alarm monitoring station and to telephone and cable services. More recently, British Telecommunications has started work on a trial fiber optic network that will link 400 homes and offices to such services as television channels, stereo audio channels, telephone, a video library, and videotext. Although, the network now is in the first stages of a two-year trial, it is expected to help generate further interest in fiber optic technology in England. By 1996, the total European market could reach more than $820 million, according to Frost & Sullivan, Inc. Design News reports a forecast of $4.3 billion worldwide by 1996 for all fiber optic products, including optoelectronic devices.

U.S. IMPORTS AND EXPORTS OF COMMUNICATIONS EQUIPMENT

For the year 1990, U.S. imports of communications equipment totaled $8.6 billion, an increase of 2% over 1989. Exports of communications equipment increased 1% in 1990 to $6.8 billion, resulting in a trade deficit of $1.77 billion (Table 2-10).

Leading exports were radio transceivers at $1.1 billion and radar apparatus and parts at $784 million.

The major imported products included telephone instruments at $943 million and cordless telephones at $588 million.

Imports and Exports of Communications Equipment ($ Million); United States, 1989-1990 **TABLE 2-10**

	1989	1990
IMPORTS		
Telephone Switching Equipment and Parts	364.3	417.1
Telephone Instruments	899.2	943.4
Cordless Handset Telephones	580.1	587.7
Intercom Systems	15.9	18.4
Telephone Answering Devices	354.3	347.9
Other Telephonic Equipment and Parts	735.0	674.6
Telegraph Apparatus and Parts	377.4	370.1
Other Telegraphic/Telephonic Equipment	963.8	776.6
Television Cameras and Parts	236.7	294.5
CB Radio Receivers	.6	.4
Other Radio Receivers	112.1	114.8
CB Radio Transceivers	103.1	93.3
Other Radio Transceivers	546.2	489.2
Antennas	169.4	163.4
Transmitters	24.3	30.4
Paging Receivers and Alerting Devices	89.8	114.4
Other Radio Equipment	922.1	1,189.0
Radar Apparatus and Parts	219.7	197.7
Radio Navigational Aids	240.7	250.3
Communications Satellites	17.5	16.2
Other Communications Equipment	1,436.9	1,483.6
TOTAL	8,409.1	8,573.0
EXPORTS		
Telephone Switching Equipment and Parts	406.3	599.0
Telephone Instruments	305.8	190.0
Other Telephonic Equipment and Parts	941.0	649.7
Teleprinting and Teletype Machines	14.0	14.4
Other Telegraphic Equipment and Parts	788.0	366.0
Television Cameras and Parts	68.4	109.1
Video Tape Players and Recorders	141.0	117.1
Office-Type Audio Tape Recorders	*7.7	6.8
Radio Receivers	271.8	286.7
Radio Transceivers	657.1	1,136.9
Antennas	434.9	463.9
Transmitters	400.3	463.6
Other Radio Equipment	1,263.1	1,278.4
Radar Apparatus and Parts	770.4	784.2
Radio Navigational Aids and Parts	254.0	330.1
TOTAL	6,723.8	6,795.9

*No longer included in this category
**Included in Other Antennas
SOURCE: U.S. Department of Commerce.

Computers and Industrial Electronics

U.S. factory shipments of computer and industrial electronic products totaled an estimated $83.4 billion in 1990, up 3.4% from $80.6 billion in 1989.

This sector includes computing and data processing equipment, testing and measuring apparatus, nuclear electronic devices, medical equipment, control and processing equipment, and other electronic systems and equipment.

Electronics are continually being incorporated into new types of equipment that had formerly been confined to mechanical operations, resulting in more efficient production.

Industry and office executives are finding it necessary to update facilities with electronics in order to handle work loads efficiently and remain competitive. The demands for higher accuracy, fast response, and the need for increased industrial productivity, along with the declining cost of computers and industrial controls, economically justifies the expanded purchasing of computer hardware and software and high-performance industrial electronics.

COMPUTERS

The outlook for 1991 is mixed, with increased foreign competition, increasing dependence on the export market, defense-related spending being cut with each new fiscal year, and slower domestic business in a softer economic climate, all combine to lower capital spending.

Within the computer industry, there are segments of strong growth, offset by maturity in such large blocks of the business as mainframes and minicomputers. In the near term, supercomputers are likely to experience slower growth, but new generations of supercomputers already on the drawing board will allow people to do things they could not have dreamed of doing with the current generation of supercomputers. Lower-priced versions of supercomputers, mini-supercomputers, are poised for growth in niche areas, where specific high-speed needs can be met by lower-cost computing devices.

Some of the factors that make this industry so progressive and dynamic are the very elements that cause buyer caution. New generations of systems are developing at a rapid rate, and the software to take advantage of the increased power is becoming more user friendly.

Clearly the industry is going through a transitional, if not a restructuring period. The trend continues to be toward desktop computers and networks as increased power and speed are built into hardware, while systems are becoming less proprietary and more open. Forrester Research, Inc. believes that a new standard, "client/server computing" will emerge as a separate and distinct market, growing to a $29.4 billion business in 1993. While the mainframe and minicomputer markets were defined by size and application, the client/server market is defined by software architecture. This network approach is expected to evolve from a UNIX multi-tasking network phase to one dominated by PC's and ultimately by full networks with associated software and data management services.

Personal Computers

Desktop Computers

According to BIS CAP International, 11.4 million PC's will be sold in the U.S. in 1991, growth of 8.6% over 1990. The *U.S. Industrial Outlook '91* states that in 1990, PC shipments to the U.S. market totaled 10.7 million units. In 1990, the value of the U.S. PC market (including imports) totaled $31.8 billion, up 13.6% from 1989.

The PC business is undergoing some of the trauma that has become common in other, more mature segments of the electronics industry. Prices have dropped as larger numbers of domestic and foreign competitors have put off-the-shelf components into standard designs. As happened in the consumer electronics business some years ago, foreign manufacturers have increased their share (from 10% in 1985, to 26% in 1990), while the cumulative share of the top ten brands has fallen from 80% in 1985 to 56% in 1990. Despite signs of maturity, innovation continues with an increasing array of software, along with a vast array of options and accessories to customize a machine to the needs of any particular user.

Another way of segmenting the PC market is by end use. The largest segment continues to be for business/professional use, at about two-thirds of the total market. According to the International Data Corporation, this segment accounted for sales of 6.9 million units in 1990, an increase of 9% over 1989. The next segment, science/technology use, increased PC buying by 21% last year, acquiring the lion's share of newer, faster, more versatile systems. Another segment, educational use, grew by 7% in 1990. This category has some exciting growth potential ahead, as multimedia applications begin to facilitate the education process.

Factory Shipments of Industrial Electronic Equipment by Type ($ Million); United States, 1981-1990

TABLE 3-1

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Computer and Peripheral Equipment	29,099	33,285	37,132	46,486	47,629	47,031r	51,889r	53,721	53,997	56,155
Control and Processing Equipment	6,717	6,523	6,186	7,294	7,410	7,677	7,892	8,535	9,361	9,550
Testing and Measuring Equipment	4,144	4,695	5,200	6,279	6,008	5,736	6,009	5,807	5,701	5,415
Nuclear Electronic Equipment	447	546	490	480	519	560	601	616	636	675
Medical Electronic Equipment	3,380	4,402	4,845	5,148	5,028	5,111	5,576	6,015	6,911	7,480
Robots, Accessories, and Components	na	na	na	281	345	346	284	229	256	275
Other Electronic Systems & Equipment	3,868	3,869	3,412	3,506	3,371	3,481	3,797	3,825	3,754	3,800
TOTAL	47,655	53,320	57,265	69,474	70,310	69,942r	76,048r	78,748	80,616	83,350

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

Portable Computers

In 1990, U.S. sales of portable computers totaled $5.4 billion (50% of total worldwide sales), an increase of 30%. Sales of portable, laptop and notebook computers are forecast to grow 24% in 1991, according to the Data Analysis Group. The line between the capabilities of portable computers and desktop units continues to blur as portable computers combine the power of desktop computers with the flexibility demanded by more and more computer users.

Workstations

According to the *U.S. Industrial Outlook '91*, workstation sales totaled $8.5 billion in 1990, a 37% increase over 1989.

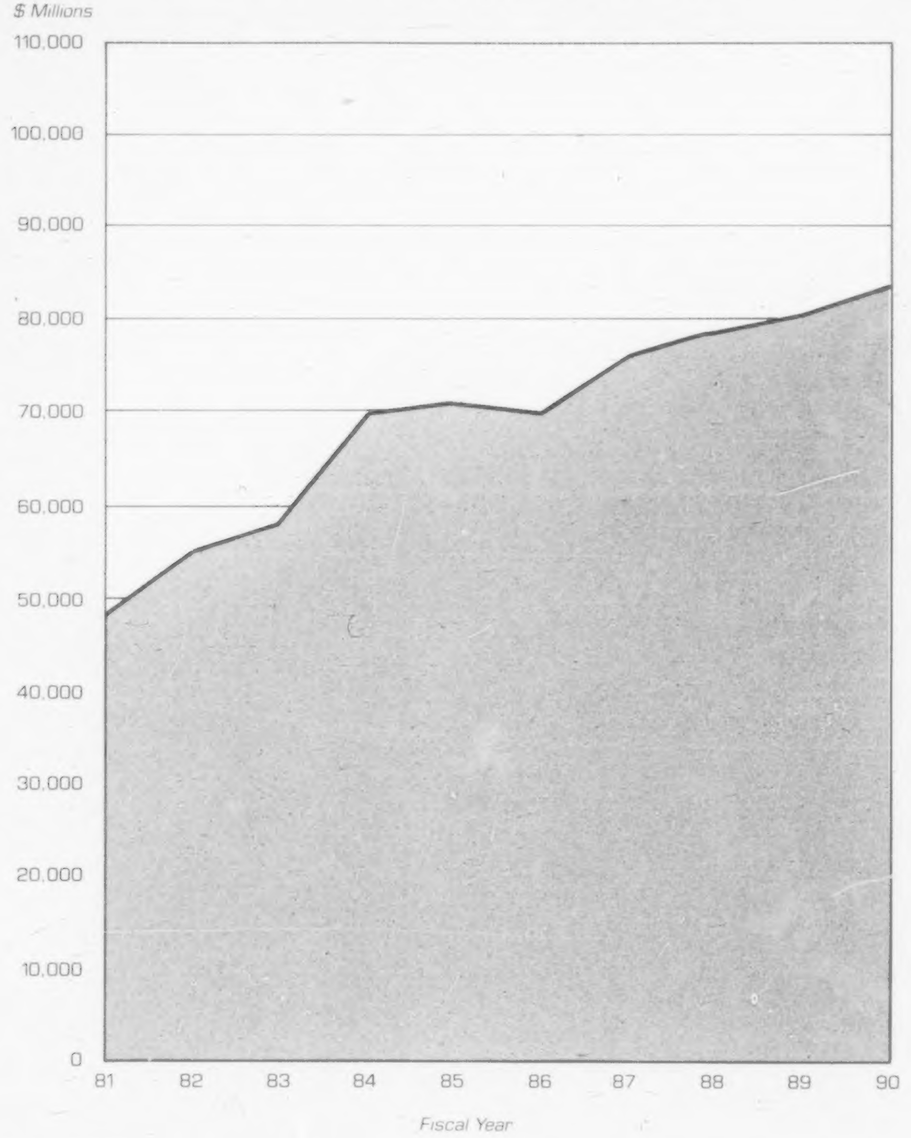
Factory Shipments of Computers ($ Million); United States, 1981-1990

TABLE 3-2

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
General-Purpose Computers:										
Digital										
Less than $500[1]	10,120.4	10,482.7	11,588.5	243.7	279.7	195.6	343.8	261.8	80.4	75
$500 to $999				739.9	659.4	274.8	514.6	334.3	186.6	150
$1,000 to $2,499				3,577.2	2,239.8	1,910.0	2,204.3	2,399.7	2,698.0	2,920
$2,500 to $4,999				545.6	2,359.6	3,376.1	4,822.2	5,045.9	5,574.6	6,000
$5,000 to 14,999				1,079.0	1,506.2	1,223.8	1,502.7	2,750.7	3,947.8	4,500
$15,000 to $49,999				2,690.0	2,513.4	2,894.5	3,114.6	3,996.3	3,236.3	3,000
$50,000 to $249,999				4,258.6	2,906.8	2,715.8	2,715.7	2,402.2	3,062.1	3,250
$250,000 to $1 Million				1,127.3	2,469.1	2,995.2	2,905.7	654.6	588.1	600
Over $1 Million				1,037.3	1,613.5	1,716.2	1,987.6	2,714.6	2,922.8	3,100
Analog	96.8	87.3	83.9	21.3	19.8	14.8	34.4	41.3	28.5	30
Hybrid										
Special-Purpose Computers:										
Digital	457.0	637.0	846.2	1,517.2	2,429.7	2,085.6	2,322.5	2,343.7	2,560.1	2,700
Analog	111.9	148.6	183.6	226.3	295.4	623.1	744.6	842.3	486.4	450
Hybrid										
Parts for Computers	1,652.3	3,201.0	3,585.5	5,468.9	4,508.7	4,810.3	4,565.1	4,339.0	3,700.2	3,800
TOTAL	12,438.4	14,556.6	16,287.7	22,532.3	23,801.1	24,836.4	27,777.8	28,126.4	29,071.9	30,575

[1] All prices at retail.
r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

U.S. Factory Shipments of Industrial Electronic Equipment, 1981-1990 **FIGURE 3-A**



SOURCE: U.S. Dept. of Commerce

Alex. Brown & Sons predicts the workstation market will reach $10.6 billion in 1991. Like most other segments of the computing industry, workstations have expanded beyond their original niche. Originally geared for the scientific/technological community, workstations have performed well in CAD/CAM/CAE due to their multi-tasking capabilities, easy access to external data, and extensive networking abilities. In addition to CAD/CAM/CAE, another computer-aided function, computer-aided software engineering (CASE), has been developed. At the high end of this market, workstation power and capabilities overlap the mainframe and mini-computer markets. At the lower end, the lines are blurring between workstations and high performance PC's. As more workstation software is being developed for the lucrative business/commercial markets, workstations are beginning to have a large impact in the electronic publishing, business graphics, financial services, and office automation markets. Despite the efficiencies realized in moving data around in a network environment, mainframes remain the best resource for storing and handling large databases.

Mid-Range Computers

Mid-range computers, according to the *U.S. Industrial Outlook '91*, range in price from $25,000 to $500,000. They are used by the service sector, durable goods manufacturers, and by government and education. Sales of this type of computer were $20 billion in 1990. These systems are designed to fill specific niches in combination with integrated software.

Mainframes

The mainframe computer was the original colossus in the data processing industry. It continues to support large numbers of users by providing general-purpose data processing functions such as payroll, accounting, order entry, etc. The installed base of mainframe computers in the U.S. reached 4,700 units in 1990, according to Computer Intelligence. It also continues to generate large revenues for its manufacturers, over $13 billion in 1990. Sales are forecast to increase 3% in 1991 to $13.4 billion, according to the U.S. Department of Commerce. The rapid growth of technical workstations, as well as business microcomputer workstations and desktop computers, in combination with local and wide-area networking could phase out many central mainframe systems in favor of a central corporate database and systems support mainframe.

Mini-Supercomputers & Supercomputers

Moving up the scale from mainframes in today's computing environment are two versions of supercomputers: the mini-supercomputer, whose low-end falls in the same price range as mainframes ($1-5 million), and whose higher prices are in the $5-10 million range; and the ultimate scientific supercomputer, selling in the $10-15 million range.

The growing mini-supercomputer market had estimated sales of $925 million in 1990, according to the Data Analysis Group. These units differ from general purpose mainframes in that they have special architecture for specific applications. Like the minicomputer's role between PC's and mainframes, these units fill a void between the high-end technical workstations and the huge scientific supercomputers.

The Data Analysis Group estimates that 1990 sales of supercomputers in the U.S. market totaled $1.8 billion. While 320 supercomputers were shipped worldwide in 1990, the 1991 forecast is for shipments of 353 units.

PERIPHERAL EQUIPMENT

Storage Equipment

According to the Data Analysis Group, U.S. shipments of hard disk drives will reach $19.4 billion in 1991, a 9% increase. At the same time, U.S. shipments of floppy disk drives are expected to reach $2.6 billion, a decrease of 3.7%. According to Dataquest, the 5.25-inch market will decrease by 17% between 1989 and 1994, while the 3.5-inch segment will grow by 23%. The surge in smaller-footprint desktops and portables is fueling the acceptance of the 3.5-inch product. Far from writing obituaries, the industry still needs to support the 5.25-inch format—particularly in the rest of the world, for years to come.

Manufacturers of magnetic tape drives and storage devices are enjoying benefits of the trend toward more archival storage. According to Freeman Associates, worldwide shipments of digital audio tape (DAT) storage devices will reach 150,000 units in 1991, while 8mm storage devices will reach 140,000 units.

Optical Disk Technology

Frost & Sullivan forecasts the U.S. market for optical storage devices to reach $4.8 billion by 1993. Optical disk shipments totaled 609,200 units in 1990-according to Freeman Associates.

The word "optical" has caught the imagination of almost everyone in the electronics industry. The technology that produces consumer audio and video discs is present in the huge storage capabilities of CD-ROM, CD-I (Interactive) and DVI (Digital Video Interactive) applications. *Computerworld* magazine observed that "just as we were getting used to such basic computing components as transistors, very large-scale integrated circuits (VLSIC's) and gallium arsenide semiconductors, we may soon find ourselves speaking of diffraction gratings, holograms and polarizers, as well as transphasors, a sort of optical transistor with potential switching speeds measured in trillionths of a second."

Computer Terminals

The U.S. installed base of X window display terminals reached 420,000 units in 1990, and sales of 240,000 units are forecast for 1991, according to Summit Strategies. At the low end of the alphanumeric display market (units selling for less than $1,000), price competition has forced manufacturers to add more sophisticated features, such as limited screen editing, to achieve product differentiation and to slow price erosion. Semiconductor suppliers, by fashioning more complex integrated circuits for display control, have helped reduce the number of components per terminal, thus simplifying assembly and lowering costs.

Touch-controlled terminals consist of a touch-sensitive grid placed on top of the CRT screen, and an internal program that allows users to command the computer solely by touching a symbol displayed on the screen. Airline companies would especially benefit from such equipment, since it would allow travelers to select their own flights and seats and pay for tickets automatically, without assistance from ticket agents.

Printers

Fierce competition and rapid technological advances are making computer printers faster, smarter, cheaper and more versatile. New capabilities and functions are being added to printers so that they will be able to meet the increasing word processing and desktop publishing needs of the business sector. The newest printers have higher print speeds, are more durable, and have other features such as color graphics, higher print resolution, lower noise levels, and multiple print modes.

According to Data Analysis Group, U.S. sales of printers reached $10.6 billion in 1990, and are forecast to reach $11.0 billion in 1991. Impact printers are expected to show a decline in sales of 4% in 1991, to $4.8 billion, while sales of nonimpact printers, such as laser printers, are forecast to increase 11% to $6.2 billion.

Software & Operating Systems

According to the U.S. Department of Commerce, the U.S. software industry had sales of $29 billion in 1990, an increase of 20% over 1989. The most recognizable segment of the U.S. software industry, prepackaged software, recorded sales of $7.3 billion in 1990, and is expected to reach $8.2 billion in 1991, according to the Data Analysis Group.

Software sales could get a significant boost in the years to come from the widespread application of multimedia. The Information Workstation Group forecasts a $10.3 billion business for multimedia products in 1994, excluding the consumer segment. The forecast for multimedia is divided into business presentation ($4.4 billion), information retrieval ($3.4 billion) and education/training ($2.5 billion). With the ability to handle massive data volumes, the incorporation of video (with its massive band-width requirements) has become a reality—particularly with video signal compression techniques.

INDUSTRIAL AUTOMATION

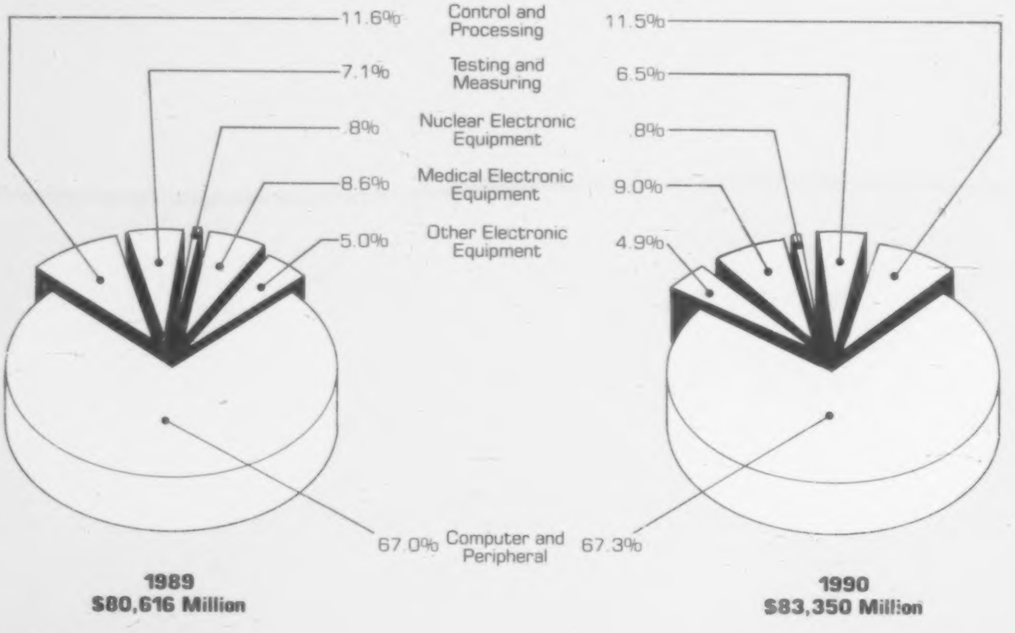
Industrial automation refers to the use of programmable machines for enhancing productivity in discrete manufacturing processes. There are five major types of automation equipment manufactured in the U.S.: programmable controllers, software-based process control systems, loggers and recorders, sensors and activators, and data acquisition equipment.

Some experts expect U.S. vendors to lose market share where the industrial automation product is primarily hardware-related. Vendors from the Far East are expected to continue, to develop cost and manufacturing superiority in these hardware areas. Machine tools, robots, and automated guided vehicles, are examples of familiar industrial automation hardware.

U.S. factory shipments of control and processing equipment were $9.6 billion in 1990, up 2.0% from the 1989 level of $9.4 billion (Table 3-4).

Industrial controls are used for starting, speed-regulating, stopping, and protecting electric motors. Some controls have specific applications, such as metal mill controls, crane and hoist controls and machine tool controls. Demand for industrial controls varies with levels of investment in new plant and equipment. Programmable controllers are finding many new applications in the process industry because they offer functions such as advanced control algorithms. They are used in a number of industries including communications networks, and manufacturing quality control.

Distribution of Factory Sales of Industrial Electronic Equipment by Type (%); United States, 1989-1990 **FIGURE 3-8**



1989
$80,616 Million

1990
$83,350 Million

SOURCE: Table 3-1.

The two leading process and control instruments continue to be numerical controls and testing/inspection equipment. The growth of numerical controls is due to the development of integrated computer numerical controls, which enable users to control and synchronize a variety of machines, and to link these machines to a central computer. New opportun-

Factory Shipments of Computer Peripherals ($ Million); United States, 1981-1990

TABLE 3-3

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Auxiliary Storage Equipment:										
Direct Access Storage:										
Rigid Magnetic Disk Drives	4305.9	3727.0	3994.5	4401.2	4630.1	4,532.1	4,349.5	5,362.6	4,930.1	4,980
Flexible Magnetic Disk Drives				697.1	527.3	415.2	330.8	224.9	374.0	400
Optical Disk Drives[1]	na	na	na	na	na	na	130.7	116.8	186.3	280
Other	418.0	339.7	323.3	325.4	336.7	423.8	675.2	462.9	399.3	350
Serial Access Storage (Magnetic Tape Drives)	776.6	812.4	772.3	890.9	1,111.4	878.8	846.7	1,381.3	1,464.4	1,565
Magnetic Storage Media:										
Disks:										
Rigid	234.6	738.7	1053.7	1017.2	821.7	653.6	650.0	585.7	492.5	425
Flexible (incl. optical)	277.3	458.3	690.2	561.5	454.0	418.4	454.5	458.3	500.2	550
Computer Tape, Cassette, Cartridge, and Other Magnetic Tape	108.2	80.4	203.9	251.3	394.9	633.5	798.1	864.2	782.9	750
Input/Output Equipment:										
Key Equipment	67.5	103.4	102.5	80.3	69.6	na	399.8	381.3	357.9	340
Systems Oriented Punched Card Equipment	30.5	20.2	22.2	24.9	14.6	21.1	14.3	6.8	11.5	10
Media to Media Data Conversion Equipment:										
Output to Microfilm Recording Units	72.1	78.4	101.7	135.0	na	na	na	175.3	101.3	75
Tapeprint Units										
Card Tape Conversion										
Document Entry Conversion:										
Optical Scanning Devices	131.1	119.3	195.4	253.3	253.4	302.7	393.6	504.4	472.7	500
Voice Recognition Devices	na	na	na	na	na	na	19.6	54.2	33.2	40
Magnetic Ink Recognition Devices	108.5	136.1	91.5	78.8	59.8	44.4	65.9	124.8	115.0	120
Other										
Printers:										
Serial type	1813.4	1633.6	1921.6	1668.9	1790.9	1,992.9	2,556.2	2,404.0	2,595.4	2,800
Line type				675.6	650.9	724.5	540.7	600.1	519.2	525
Page type							226.8	457.8	669.3	835
Plotters	223.2	247.5	232.2	240.8	466.1	564.9	532.7	574.4	647.8	710
Graphic displays	133.1	164.6	188.4	192.7	166.2	145.8	149.2	243.2	201.3	205
Other input/output devices	696.8	652.9	606.1	1092.2	1156.4	717.0	1,159.0	1,052.6	877.0	885
Terminals:										
General Purpose:										
Single CRT	1891.9	2137.8	2079.9	1984.6						
Monochrome					638.0	532.5	316.0	356.2	321.8	315
Color					413.7	231.9	138.1	106.7	89.6	85
Teleprinters	433.5	496.4	449.7	369.3	170.4	496.0	319.9	305.5	224.8	200
Multistation CRT/Teleprinter	204.2	109.0	122.9	72.1	43.6	135.9	116.4	63.9	80.6	75
Other	286.1	397.5	685.5	799.2	814.6	823.8	564.8	990.5	1,072.8	1,105
Special Purpose:										
Graphic	274.6	454.5	770.1	952.0	687.3	609.6	508.0	594.0	375.9	350
Other	278.8	252.1	248.4	241.7	242.7	436.1	466.1	255.8	190.3	175
Funds Transfer	na	na	na	na	306.9	287.7	287.6	287.1	291.3	300
Point-of-sale (POS)	na	na	na	na	413.6	475.9	496.8	404.0	732.9	770
Communications Interface Equipment:										
Carrier equipment	126.5	189.9	324.0	330.3	131.7	[2]	[2]	[2]	[2]	[2]
Modems:										
Up to 2000 baud setting	60.0	37.1	70.2	71.2	108.3	[2]	[2]	[2]	[2]	[2]
2001 to 4800 b/s	104.6	61.7	160.6	101.9	88.8	[2]	[2]	[2]	[2]	[2]
Over 4800 b/s		42.8	17.2	95.6	88.9	[2]	[2]	[2]	[2]	[2]
Digital Multiplexors	349.2	388.6	437.5	491.8	523.8	[2]	[2]	[2]	[2]	[2]
Other Peripheral Equipment	608.6	1041.9	1044.9	1333.5	1632.8	1,610.0	1,450.2	633.5	595.0	575
Parts for Peripheral Equipment	2646.1	3806.6	3933.4	4523.3	4618.9	4,086.8	5,153.6	5,561.7	5,218.3	5,285
TOTAL	16660.9	18728.4	20843.8	23953.6	23828.0	22,194.9r	24,110.9r	25,594.5	24,924.6	25,580

r-Revised.
e-Estimated.
[1] Included in "Other" prior to 1987.
na-Not available.
[2] Included in Table 2-4.
SOURCE: U.S. Department of Commerce.

ities will emerge in areas such as electric discharge machines, laser machines, plasma-arc machines and ultrasonic machines.

There is an underlying trend toward interconnection in all phases of the electronic business, and the industrial controls area is no exception. Industrial "nervous systems" are foreseen in which sensors feed "expert systems" a wide variety of information for feedback control. According to *High Technology Business*, Japan's keenness for automation has proved a fertile market for U.S. sensor makers. Sensors are a vital component of an interconnected manufacturing system. Japanese manufacturers routinely include pressure sensors in computer-controlled machine tools, hydraulic robot limbs, vacuum-assisted picking tools and other automated hardware.

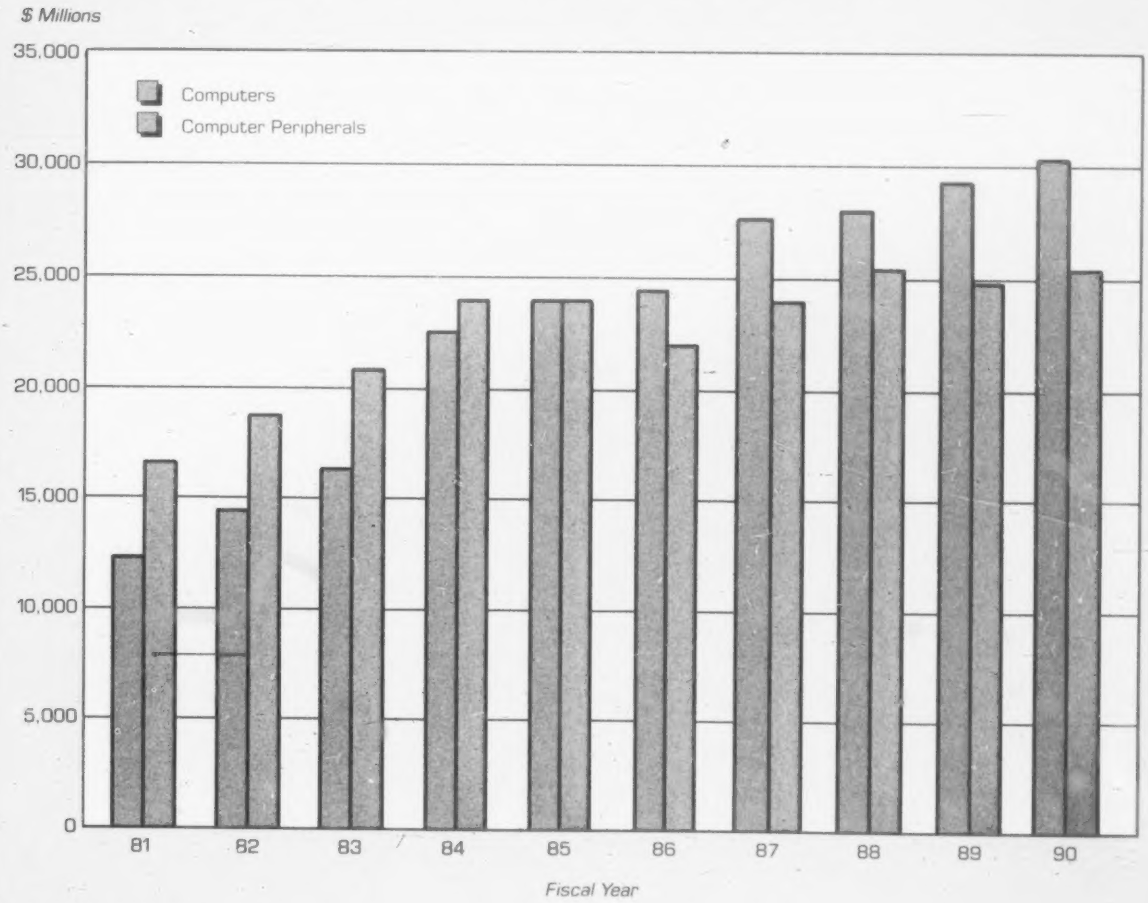
The U.S. market for industrial local area networks will continue to be dominated by U.S. vendors, according to the Automation Forum's Joint Trade Association Committee on Industrial Automation Market Statistics. However, by 1995, foreign vendors are expected to have captured more than 20% of the U.S. market.

Electronic Temperature Controls

Approximately one-half of electronic temperature indicator shipments are comprised of contact-type instruments that use thermo-couples, RTds, thermistors, or similar sensors. The other half are non-contact infrared and optical radiation pyrometers. Although non-contact thermometers are sometimes more convenient and provide higher temperatures ranges, they are more expensive and generally less accurate than contact thermometers.

In addition to segmentation by contact and non-contact techniques, each of these instrument types is configured into several distinct case styles. Almost 50% of the total dollar value of contact type thermometers is represented by panel-mounted indicators, which are used primarily in OEM and other industrial applications. Handheld thermometers account for another 40% of the contact shipments. For this type, end-user industrial and laboratory applications account for the largest share. Benchtop thermometers, which are primar-

U.S. Factory Shipments of Computers and Peripheral Equipment, 1981-1990 **FIGURE 3-C**



SOURCE: U.S. Dept. of Commerce.

Factory Shipments of Control and Processing Equipment ($ Million); United States, 1981-1990

TABLE 3-4

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Controls										
A.C. full voltage starters, contactors, reduced voltage controls, 1000 volts or less	506.1	372.2	325.9	349.7	313.7	386.4	400.8	383.1	418.9	415
Motor control centers, 1000 volts or less	288.9	214.9	242.2	250.5	282.2	261.8	243.1	251.9	336.6	350
Starters and contactors for squirrel cage and wound rotor and synchronous motors, over 1000 volts, air break and oil immersed	66.9	66.0	80.7	47.4	49.6	49.9	44.2	52.2	45.0	40
Pilot circuit devices, such as limit switches, interval timers, photoelectric devices:	131.6	213.8	200.3	305.7	271.3	323.7	362.6	424.5	463.4	465
Other general industry devices:										
Pushbuttons, Rheostats and Resistors, Brakes, Synchronous Motor Starters	425.6	242.7	266.8	319.1	282.0	301.1	305.0	340.7	364.4	360
Marine and Navy auxiliary controls and accessories	143.8	91.0	118.8	160.9	161.3	179.4	175.9	204.9	234.0	235
Metal mill		82.3	70.3							
Crane and hoist controls	42.8	29.4	20.1	28.3	26.9	20.3	25.7	37.0	37.5	35
Adjustable speed drives	281.4	270.4	245.6	320.8	353.1	381.9	440.9	522.5	593.6	600
Numerical controls	609.7	554.3	599.0	910.0	843.6	815.6	741.3	802.6	827.5	810
Other controls	898.5	702.9	605.8	654.5	568.1	537.8	606.1	667.1	749.9	750
Processing										
Temperature	118.5	118.7	97.0	131.0	137.8	128.6	181.0	175.0	157.0	150
Pressure, draft and vacuum	138.1	141.2	128.4	154.9	168.5	168.5	185.2	204.3	228.2	240
Flow and Liquid Level	557.8	547.7	508.3	585.1	623.9	593.8	628.5	694.3	774.1	805
Humidity instruments	8.9	16.6	16.2	18.9	19.1	18.5	24.4	29.0	29.2	30
Continuous process gas and liquid analysis instruments	226.9	218.9	220.5	229.7	[illegible]	233.1	238.3	276.2	324.7	345
Instruments for other variables (speed, viscosity, position, density, specific gravity, sequence, etc.) Includes mechanical types	90.1	95.6	84.3	91.7	116.5	98.5	92.7	115.9	114.4	115
Industrial process-display and control instruments (operate from standard transmitted signals, excl. aux. sta.)										
Electronic systems (unified architecture type)										
Controllers	148.6	131.4	145.4	109.4	92.0	104.6	105.7	126.6	151.7	165
Recorders	79.6	72.5	65.6	75.6	76.9	71.3	91.7	74.4	76.0	80
Indicators	30.4	32.8	32.6	26.9	40.7	35.1	36.7	41.6	43.2	45
Electronic systems (non-unified architecture type)	420.2	519.1	440.9	651.7	705.6	690.1	778.2	860.3	1,015.9	1,090
Multi-function process computers	188.3	175.3	171.2	143.6	135.4	154.0	177.9	177.9	183.5	185
Pneumatic systems (excl. aux. sta.)	78.1	62.7	78.5	62.3	66.3	60.7	59.5	64.4	66.7	68
Annunciators	33.8	33.3	13.3	20.5	36.7	38.5	22.3	25.8	26.2	27
Physical properties testing and inspection equipment	297.0	371.4	365.1	394.7	408.8	493.5	533.9	547.0	585.1	600
Kinematic test and measuring equipment	135.9	140.6	128.8	164.0	112.5	130.3	148.9	148.9	169.0	175
Automatic regulating devices	503.1	495.3	504.8	507.6	622.4	608.6	514.7	605.7	[illegible]	650
Other process instruments	266.3	509.9	409.5	579.4	621.6	791.5	727.2	680.7	[illegible]	720
TOTAL	6716.9	6522.9	6185.9	7293.9	7409.7	7,677.1	7,892.4	8,534.3	9,360.7	9,550

r-Revised
e-Estimated by EIA Marketing Services Department
SOURCE: U.S. Department of Commerce.

ily used in laboratory and industrial settings, account for the remaining 10%.

The electric thermostat and temperature switch market includes devices which perform simple on/off control of electric power in response to temperature changes. Thermostats are commonly found in appliances, including ranges, toasters, and coffeemakers, as well as on the wall for environmental control. Temperature switches control heating in industrial ovens, compressors, packaging machinery, and watering troughs for livestock feed. Plastics, food processing, and oil and petrochemical production also consume a large share of thermostats and temperature switches that perform on/off control of electric current. Solid state temperature switches have cast a shadow of uncertainty about the future of electromechanical devices used in industrial and process control. For years, manufacturers of filled temperature switches have expected a precipitous drop in price from their solid state competitors. In a sense, this shift to the electronic type is gaining momentum, but the product focus is on proportional (PID) controllers. The prices of electronic proportional controllers used in industrial temperature control are dropping to a level approaching prices paid for electronic on/off controllers. Current electronic on/off temperature switches used in industrial and process control can range in price from $50 to $500; the cost of proportional controllers ranges from $60 to $700. The prices of functionally limited and less precise electro-mechanical counterparts run from $50 to $350. The average selling prices of both proportional and on/off electronic controllers are still higher than those of filled systems. However, increasing numbers of industrial and end-users are turning to solid state devices for temperature control. Market Research Intelligence Co. sees the U.S. temperature sensor & indicator market surpassing the $2 billion mark in 1994.

ARTIFICIAL INTELLIGENCE

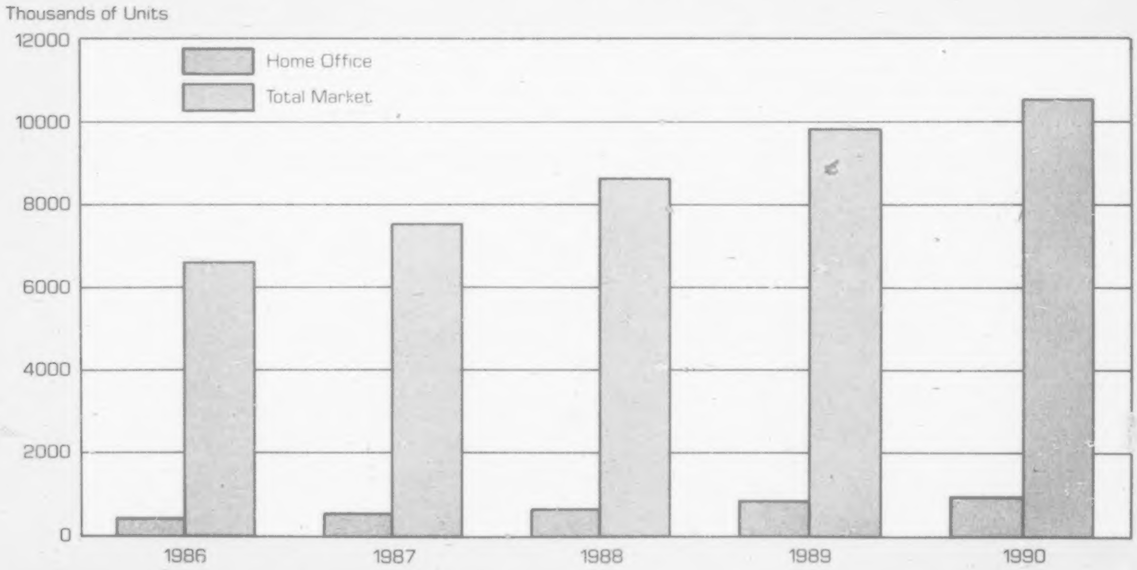
According to the *U.S. Industrial Outlook '91*, the overall growth rate of the U.S. artificial intelligence market should continue to experience overall growth from sales of $848 million in 1990. "Expert systems" have become the most commercially successful artificial intelligence (AI) application. These systems are programs that contain a knowledge base from which solutions are reached by "if-then" logical patterns. Promising work is currently being conducted in many circles AI systems which attempt to mimic the "neuron networks" of the human brain. Other AI technologies involve equipment and software that is able to see, move and communicate by processing sensory data at great speed. While robots are the most visible examples of automatic action/reaction technology, other advances in image processing known as "machine vision" devices have made great strides in manufacturing inspection, and test and measurement applications—particularly in hostile environments.

Robotics

The Robotics Industries Association reports that U.S. shipments of robotic equipment totaled $425 million in 1990, while orders totaled $500 million. The *U.S. Industrial Outlook '91* states that U.S. exports of robots and parts totaled $100 million in 1990, a 61% increase over 1989, while imports of robots and parts were $125 million.

Most U.S. robotics firms have operated at a loss during much of their existence, because robotics production combines low volume with high unit costs. Sales of robotics prod-

U.S. Shipments of Personal Computers by Market Segment, 1986-1990 **FIGURE 3-D**



SOURCE: BIS CAP International

Factory Shipments of Numerical Controls (\$ Million); United States, 1981-1990

TABLE 3-5

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
Controls for numerically controlled machine tools:										
Positioning type	31.5	14.0	14.4	18.7	16.4	19.5	20.3	19.2	20.9	20
Continuous path type	192.5	139.1	105.0	154.1	147.9	125.3	101.8	90.4	90.9	85
Digital readout systems, including dial and plug board type	46.5	35.0	32.4	22.6	18.7	18.4	19.0	18.1	19.5	20
Programmable controllers (sold separately)	339.2	366.2	447.2	714.6	660.6	652.4	600.2	674.9	696.2	685
TOTAL	609.7	554.3	599.0	910.0	843.6	815.6	741.3	802.6	827.5	810

r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

ucts are heavily dependent on the level of new investment from the U.S. manufacturing sector. Small U.S. firms entering the field find it cost effective to import basic robots and add value by tailoring software and peripherals to the needs of the end user.

Some robotics applications have reportedly yielded productivity gains of as much as 20 to 30 percent and these gains are expected to increase as new developments in robotics become commercially available. Some of the most significant potential gains could come when robots are integrated into the various forms of integrated manufacturing networks rather than in their use as stand-alone single task units. A much broader set of tasks awaits the robot as technology advances resolve the complex problems of machine vision, methods of sensing, communication, and mobility.

Two small, but promising segments of the robotics industry directly related to electronics are special non-contaminating robots for integrated circuit (IC) processing and robots for printed circuit board assembly. With IC processing pushing toward extreme cleanliness for submicron line widths, and the concurrent needs of higher productivity and yield requirements, non-contaminating robots are beginning to take a defined place in the clean room. In order to successfully compete in this changing industry, robot manufacturers are either targeting a particular industry such as autos or electronics, or concentrating on basic operations common to many industries. For example, the handling and assembly of small parts, such as electronic components, motors, and appliances, are being perfected. High-end, stand-alone vision systems are also playing an important role in speeding up the inspection of components such as multi-layer printed circuit boards. Software applications for crude vision systems have expanded to include algorithms which can determine an object's presence or absence, locate circles and their centers, and find the edges of objects. Standardized software has dramatically eased the job of system development.

The prices for robotic vision systems have declined as the technology has improved. A system which cost about \$40,000 a few years ago is now priced at \$10,000 to \$15,000. The systems have become easier to develop over the years, both in terms of hardware and software.

Robotic systems cameras are now capable of surveying a part's presence, its orientation, and the spacing between its leads. More complex systems, such as automated optical inspection (AOI) systems, are required for inspection tasks as complex as detecting errors in the artwork of multi-layer printed circuit boards. These systems may cost as much as half a million dollars. Given their high prices and capabilities, AOI systems have little in common with the integrated robotic vision products. Still, both types of systems have given manufacturers a critical edge over non-automated competitors. Companies are beginning to view vision systems as required components for electronics assembly and inspection.

Other major industries using robots include home appliances, aerospace, consumer goods, and off-road vehicles. Robots are now suitable for a wider range of industries with recent developments that give them added intelligence such as machine vision, tactile sensing, and mobility. The near future will increasingly find robots used in industries such as textiles, food processing, pharmaceuticals, furniture, construction, and health care.

Machine Vision

Machine vision systems combine the advantages of optics, advanced software, and robots, offering inspection and manufacturing capabilities that surpass all available methods. The machine vision industry is expected to reach \$350 million by 1991, an annual growth rate of 28%, according to the Freedonia Group. Due primarily to the weakened automotive industry, machine vision manufacturers are diversifying their efforts into electronics, quality control, defense weaponry, aircraft, and food processing markets.

Materials Handling

Increasingly sophisticated ways of handling materials are revolutionizing the manufacturing process. With the increasing use of robots, conveyors, automated stockrooms and techniques such as bar coding, industry has begun to see dramatic gains in productivity and efficiency from more precise inventory control, production, shipping and materials handling management. A leading manufacturer estimates that computerized materials handling sales will increase from $5 billion in 1985 to approximately $15 billion in 1995.

CAD/CAM/CAE, CIM

As part of the ever-increasing trend toward interconnecting equipment, departments, companies, industries and the world, another three-letter computer aid to the manufacturing process has evolved: computer-integrated manufacturing (CIM). With feed-back loops between the computer-aided design (CAD), engineering (CAE) and manufacturing (CAM) areas, as well as links to other functions of the business (e.g., sales, material purchasing, robot controllers, etc.) CIM enhances the complex communications process and profitability of an entire business entity.

According to the Data Analysis Group, the U.S. CAD/CAM/CAE industry generated an estimated $4.2 billion in revenues in 1990, and is forecast to reach $4.6 billion in 1991.

Computer-aided design and manufacturing systems enable engineers to rapidly design mechanical parts, analyze them to close tolerances, and directly generate machining instructions. Thus, by avoiding time-consuming and expensive manual drawing and prototype work on the shop floor, companies can significantly reduce the time and cost of developing new products. CAE extends the straightforward dimensional problems of the on-screen design of a product (CAD) to its engineering behavior. CAM does the same thing for manufacturing, by quantifying precise manufacturing standards.

Factory Shipments of Robots, Accessories, and Components ($ Million); United States, 1984-1990

TABLE 3-6

	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
Servo-Controlled Robots:							
Point-to-Point Type:							
Welding, soldering, brazing, and cutting	56.9	74.6	86.0	64.6	32.3	29.3	28
Foundry, forging, and heat treating	1.9	.7	3.2	3.4	3.2	9.3	10
Inspection, measuring, gauging and sorting							
Plastics molding/forming	NA	NA	3.7				
Metal bending, shearing/forming							
Drilling/cutting	NA	NA					
Machine tool loading and unloading	4.1	3.8					
Assembly	20.9	17.8	19.1	19.6	8.0	8.1	9
Material handling and parts transfer N.E.C. Other	35.4	44.9	45.1	48.3	27.0	26.0	25
Continuous-Path Type:							
Welding, soldering, brazing, and cutting	16.6	22.4	13.8	9.0	3.7	2.2	2
Spraying, painting, gluing, and sealing	46.0	41.4	36.9	41.3	30.1	35.1	38
Other, including fettling, grinding, polishing and deburring	24.3	49.3	48.1	16.8	33.4	25.6	27
Non-Servo-Controlled Robots	16.2	18.0	15.7	8.2	17.1	14.9	15
Other Robots, Including Educational, Hobby, and Experimental	3.3	2.8	3.0	8.6	NA	NA	NA
Robot Accessories, Subassemblies, Components and Parts Sold Separately:							
End-of-arm tooling	1.3	3.7	8.4	6.1	3.3	3.5	4
Vision, sonic, force, tactile and proximity sensors	15.2	17.7	14.8	15.6	18.2	20.5	22
Interface modules	10.8	4.9	1.7	.8	1.3	2.0	3
Compliance devices							
Joint locating and guidance systems for welding			1.2	4.0	5.7	6.3	7
Guarding and safety devices			1.7				
Other accessories, etc.	28.3	43.2	43.6	38.1	45.4	73.2	85
TOTAL	281.2	345.2	346.0	284.4	228.7	256.0	275

[r] Revised.
[e] Estimated.
NA-Not available.
[1] Complete Robots Only.
SOURCE: U.S. Department of Commerce.

Complexity of designs is not a problem for CAD/CAM. It may be used to draft and build both simple and complex parts all the way from a hinge to a robot. Engineers use CAD/CAM to design parts and machinery, generate electronic schematics, diagram complex microcircuits and printed circuit boards, calculate manufacturing specifications, list parts and furnish bills of material. Not only does CAD/CAM increase productivity, but it also shortens development cycles, causes fewer errors, and cuts labor requirements. In short, CAD/CAM eliminates the high cost of preparing a part for manufacture.

The import/export trade balance may be staggering in other electronic industries, but U.S. CAD/CAM manufacturers have yet to feel the full sting of foreign competition. CAD/CAM is software driven and since American manufacturers currently hold the technological upper hand in software development, U.S. producers enjoy a substantial competitive advantage over their overseas counterparts. The European nations are the leading buyers, followed by Japan. Predicasts, a market research firm, expects U.S. exports to grow to $2.2 billion by the mid-1990s. Hardware will remain the most costly element of a CAD/CAM system, reports Predicasts, but software continues to claim an ever-increasing share of CAD/CAM expenditures, and could represent 35% of the industry total by the mid-1990s.

New industrial applications are also being developed that will assist engineers in special programs for structural, thermal, and circuit analysis. New programs will allow verification of such items as tool clearances, cutter paths, and fixtures.

TESTING, MEASURING AND ANALYZING EQUIPMENT

U.S. factory shipments of electronic testing, measuring and analyzing equipment are estimated at $5.4 billion for 1990, down 5.0% from 1989 shipments of $5.7 billion (Table 3-7).

These instruments are used for measuring, testing, and analyzing a wide range of electrical and electronic variables such as current, resistance, capacitance, inductance, frequency, and waveform. They are employed extensively in manufacturing plant inspection stations; laboratories; research establishments; appliance, television, and radio repair shops; automobile garages; and other service industries.

Test equipment is also used for control purposes to improve yields during the manufacture of discrete components. This includes use of devices to control "spiraling" resistors to a specific value and instruments for winding capacitors to a predetermined capacitance.

Trends in the industries which use testing and measuring equipment have a strong impact on demand on electrical test and measurement instruments. The electronics industry uses automatic test equipment (ATE) to test semiconductors and printed circuit boards.

Increasingly, manufacturers are introducing specialized test equipment such as ATE for field-service use. Such equipment can reduce test costs greatly for a particular application, although the need for specialized design also limits adaptability for other uses. Manufacturing-defect analyzers (MDAs) are selling at a rapid pace due to their low cost. These limited capability in-circuit testers offer an alternative to the traditional board testing methods. In addition, the short production runs and complexity of application-specific integrated circuits are encouraging manufacturers to develop instruments which readily generate test programs from computerized design specifications.

Digital oscilloscopes are now challenging analog scopes for general purpose uses. Sales of digital oscilloscopes have grown rapidly with the introduction of high-performance models priced competitively with analog models. Analog scope manufacturers, unable to meet the demand for high performance scopes, have experienced some erosion of their markets.

POWER SUPPLIES

The electronic power supply industry includes plug-in, linear, switcher, uninterruptible, line conditioner, and high voltage power supplies. According to Mirco-Tech Consultants, the U.S. power supply industry is expected to grow from $6.1 billion in 1989, to $7.6 billion in 1993, with switches increasing their share to more than 63% of the business. New "smart power", or integrated circuits that bundle a power switching element with logic control circuitry, are just beginning to reach critical mass in terms of market demand. Dataquest, Inc., sees world demand growing to $2.4 billion in 1995, while U.S. demand will account for $1.66 billion in the same time period.

According to Venture Development Corporation, the U.S. market for uninterruptible power supplies (UPS) surpassed the $1 billion mark in 1989, and should exceed $2 billion in 1993. Shipments of off-line UPSs will increase at significantly higher rates than shipments of on-line UPSs during the next few years. The major factor expected to contribute to the growth of UPS shipments is service sector's response to frequent irregularities in electrical power provided by commercial sources. UPSs are regularly being used more and more to minimize these problems, because they are capable of maintaining total continuity of electric power to a critical load. The UPS isolates a critical load from the voltage fluctuations, frequency variations and electrical noise associated with utility-supplied electric power during normal operation. If the utility-supplied electric power should fail, the UPS provides clean and stable electric power to critical load, until an orderly shutdown is accomplished, an auxiliary power source is substituted, or utility-supplied electric power is restored.

Also contributing to the accelerating demand for UPS is the continuing rapid growth in many of those industries and service sectors generating UPS applications. Among those industries and service sectors are data processing, process controls, communications, utilities, military/aerospace, and medical laboratory. While industry analysts expect UPS shipments to all business segments to continue to increase, only the data processing segment is expected to gain market share over the next few years.

NUCLEAR ELECTRONIC EQUIPMENT

Nuclear electronic instruments perform radiation detection, measuring, and control functions. The instruments are applied in nuclear reactor operations in radioisotope utilization, in industrial and food processing, and in the medical, scientific and educational fields.

Factory Shipments of Testing and Measuring Equipment ($ Million); United States, 1981-1990

TABLE 3-7

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
A.C. watt-hour meters	137.5	142.9	179.3	181.1	197.1	186.1	183.0	157.4	173.7	170
Combined watt-hour and demand meters and time switch meters	72.7	69.6	74.8	85.4	94.4	103.2	101.4	118.6	112.5	105
Other integrating meters and instruments, and parts	93.5	126.5	103.9	151.9	111.1	113.6	116.0	111.6	97.6	90
Voltage, current and resistance measuring equipment	148.6	208.5	228.8	269.9	276.0	260.9	302.3	283.8	293.8	285
Multimeters	107.4	105.1	103.9	126.6	132.9	127.0	136.4	132.1	164.8	160
Power and energy measuring equipment	14.5	19.3	53.8	59.2	80.2	101.0	98.4	79.1	89.9	85
Frequency measuring	91.9	98.4	108.7	113.9	136.6	123.5	112.2	104.1	108.7	105
Waveform measuring and/or analyzing equipment	588.0	675.5	678.2	738.6	743.5	679.3	658.3	406.7	420.2	405
Signal generating equipment	280.7	278.6	327.8	351.2	315.3	324.7	356.8	279.0	297.0	285
Field strength and intensity measuring	108.8	128.9	155.4	211.4	248.8	231.3	na	na	na	na
Impedance and standing wave ratio measuring	43.1	49.7	35.9	54.4	43.7	49.0	48.2	48.8	43.5	40
X-Y plotters	137.8	167.5	182.6	263.4	34.1	33.7	19.3	15.9	7.9	9
Time measuring & counting equipment	36.5	31.5	na	na	na	na	na	na	na	na
Automatic test and measuring equip.:										
Combination/Group test sets	498.2	562.6	621.1	553.4	611.0	590.1	622.2	506.0	530.1	525
Component part test sets:										
Electron tube	1.6	256.4	2.5	2.3				1.4	1.3	1
Semiconductor	248.7		246.8	475.6	469.6	459.5	564.5	580.6	496.8	460
Other	26.9	69.0	115.6	201.2	182.6	236.0	459.3	533.5	522.3	495
Other	174.1	190.4	201.5	183.2	159.9	167.6	297.8	390.6	372.8	350
Standards and calibration	116.0	133.8	132.5	130.7	183.8	145.0	185.9	195.7	185.8	175
Microwave test[1]	95.7	120.5	33.6	36.2	34.3	34.8	47.2	54.3	45.1	40
Communications test (excl. microwave)	na	na	39.0	178.3	262.5	259.4	363.4	446.4	452.0	440
Internal combustion engine analyzers	272.9	220.9	232.3	306.6	311.6	296.1	273.6	280.8	272.8	260
Associated devices for testing and measuring	60.4	77.8	117.6	225.4	na	na	na	na	na	na
Other test, measuring and analyzing	788.1	961.6	1224.8	1379.2	1378.9	1,214.0	1,062.5	1,080.1	1,012.8	930
TOTAL	4143.6	4695.0	5200.4	6279.1	6007.9	5,735.8	6,008.7	5,806.5	5,701.4	5,415

r-Revised.
e-Estimated by EIA Marketing Services Department.
[1] Includes 1300 MHz and above only subsequent to 1982.
na-Not available.
SOURCE: U.S. Department of Commerce.

U.S. shipments of nuclear electronic equipment increased to $675 million in 1990, up 6.2% from the 1989 level of $636.4 million (Table 3-8). Most of the increase can be attributed to the strong market for medical monitoring systems and measurement and controlling devices. These devices are used in semiconductor equipment and medical instruments, products which have been in high demand recently.

MEDICAL ELECTRONICS

The rate at which both new and traditional medical, surgical, and dental instruments, and other health care products incorporate semiconductor devices, such as microprocessors and other advance electronic components, has increased gradually over the past decade. In 1990, U.S. shipments of electromedical equipment reached an estimated $7.5 billion, up 8.2% from the 1989 level of $6.9 billion (Table 3-9). Exports of electromedical equipment totaled $1.8 billion in 1990, while imports totaled $1.0 billion, according to the U.S. Department of Commerce. The electromedical equipment industry consists of some 260 manufacturing establishments, the top 20 of which account for 74% of industry shipments.

Electromedical diagnostic and therapeutic equipment is the largest product category of the electromedical equipment industry, accounting for nearly two-thirds of industry shipments. Products in this sector include electrocardiographs, electroencephalographs, pacemakers, defibrillators, patient monitors, ultrasonic scanners, magnetic resonance imaging devices, and surgical support systems. Technology developed in the semiconductor and computer industries is increasingly being used to improve and develop electromedical products.

Examples of such products currently in use, or under development, are ultrasonic, radiologic, and nuclear magnetic resonance imaging devices that show clear pictures of internal organs; sophisticated aids for handicapped persons that can provide limited artificial sight, hearing, and speech; implanted programmable prosthetic devices; as well as greatly improved patient-monitoring systems, automated clinical laboratory analysis units, and computer-based medical information systems that handle a myriad of financial and administrative records, patient medical data, medical diagnostic data, pharmacy inventories, and medical service scheduling.

U.S. shipments of electromedical devices are projected to grow 6% in 1991. Growth in this industry could be spurred in the coming years by the aging of the U.S. population, and U.S. government efforts to limit health care expenditures by promoting increased use of early diagnostic techniques.

Factory Shipments of Nuclear Radiation Detection and Monitoring Instruments ($ Million); United States, 1981-1990 **TABLE 3-8**

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Radiation detecting elements, including chambers, sold separately	46.6	46.6	39.0	38.4	35.7	36.8	65.3	66.9	69.0	73.0
Solid state detectors sold separately				14.2	16.9	19.9	19.5	21.7	35.2	40.0
Nuclear monitoring instruments, including environmental, personal dosimetry, and medical monitors, stationary and portable	89.4	103.9	93.7	126.6	120.6	125.9	126.4	111.7	137.0	145.0
Medical and biological counting systems for in vivo counting										
Sample and flow counting systems	33.5	28.7	29.5	34.7	36.0	33.1	30.7	35.1	28.8	30.0
Scalers sold separately	4.6	12.1	11.2	2.5	2.4	4.2	4.9	8.9	3.3	3.5
Special amplifiers for nuclear applications	4.4	5.7	6.1	7.1	5.2	4.2	4.0		4.3	4.5
Pulse analyzers, including nuclear spectrometers	30.7	32.9	28.9	27.7	20.4	33.8	27.3	28.9	25.4	27.0
Count rate meters	10.2	.9	1.6	9.1	6.6	4.6	3.9	2.8	3.1	3.5
Measurement and control devices using beta, gamma, or neutron gauge technology	108.1	129.9	106.7	119.1	128.1	133.1	160.4	186.1	198.3	220.0
Input-output accessories for multichannel analyzers	2.8	1.5	1.8	7.6	12.4	10.6	9.9	13.1	13.7	14.5
Nuclear power supplies	8.6	9.4	5.4							
Neutron & photon activation analysis systems										
Nuclear instrument modules	29.4	27.7	25.4	17.9	16.9	17	29.1	27.6	30.9	34.0
Other nuclear radiation detection and monitoring instruments	78.8	146.8	140.2	74.8	117.4	136.4	119.3	113.1	87.4	80.0
TOTAL	447.1	546.1	489.5	479.7	518.6	559.6	600.7	615.9	636.4	675.0

r-Revised.
e-Estimated by EIA Marketing Services Deparment.
SOURCE: U.S. Department of Commerce.

Factory Shipments of Electromedical Equipment ($ Million); United States, 1981-1990

TABLE 3-9

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Electromedical equipment (other than irradiation equipment)										
Diagnostic Equipment:										
ECGs	114.3	88.2	72.3	117.6	78.1	73.3	85.1	98.5	91.7	100
EEGs and EMGs	6.7	14.8	14.5	19.6		.9	2.9		19.6	21
Ultrasonic scanning devices	267.0	299.5	376.3	294.2	171.9	243.9	336.6	416.8	520.1	575
Audiological equipment	42.8	72.4	10.2	11.5	12.3	13.6	22.5	17.6	22.9	25
Endoscopic equipment			3.0	10.2	10.6	25.5	35.2	22.3	13.0	13
Respiratory analysis equipment	15.6	17.7	15.6	17.1				22.7	24.4	25
Automated blood and body fluid analyzers	439.7	641.1	744.3	715.3	631.9	571.6	617.2	579.2	723.5	800
Nuclear magnetic resonance imaging devices	—	—	360.0	81.2	210.9	250.4	466.0	577.0	640.2	680
Other diagnostic equipment	194.9	345.4		254.1	275.8	201.1	322.8	457.7	483.6	500
Therapeutic equipment:										
Pacemakers	258.1	319.1	263.5	370.6	293.5	345.1	284.3	496.8	573.8	620
Defibrillators	67.8	80.1	85.6	90.7	103.6	118.3	141.3			
Electrosurgical equipment	47.0	23.1	63.6	80.5	80.2	100.8	125.2	133.9	163.4	180
Diathermy apparatus and dialyzers[1]	143.9	32.6	72.6	65.5	88.9	85.2	94.6	134.6	151.4	160
Ultrasonic therapeutic equipment	3.9	9.4	17.9	31.7	27.1	26.0	35.3	30.2	38.1	42
Other therapeutic equipment	160.0	241.3	274.4	280.3	224.7	154.1	190.6	233.7	258.1	270
Patient monitoring equipment										
Intensive/coronary care units	218.4	271.9	298.1	280.2	352.2	301.7	283.8	367.9	373.7	380
Perinatal monitoring equipment	22.4	42.6	70.9	50.9	64.2	67.7	95.6			
Respiratory monitoring equipment	10.7							23.0	19.0	19
Other patient monitoring	167.4	289.9	289.7	245.7	248.2	228.7	252.4	255.0	333.9	380
Surgical support systems	55.4	108.1	103.7	129.5	177.4	216.9	226.7	273.4	325.9	355
Parts and accessories for above	140.5	162.9	164.9	244.1	300.8	300.0	386.4	455.9	562.6	620
Irradiation equipment:										
Medical x-ray equipment										
Diagnostic										
Digital radiography	652.7	972.1	1135.3	59.9	31.2	39.1	29.4	38.5	38.0	40
Computerized axial tomography				666.4	528.7	905.3	815.8	704.1	862.9	965
Other				420.3	429.7					
Therapeutic	61.1	64.9	66.8	96.5	105.7	115.8	131.6	na	na	na
Dental x-ray equipment	26.4	26.9	17.0	37.9	45.4	33.4	16.9	na	na	na
Industrial and scientific X-ray equipment	42.4	38.1	65.4	52.5	61.0	66.0	71.0	82.0	94.3	105
X-ray equipment accessories	64.5	70.7	98.5	137.9	158.5	118.3	117.7	111.1	132.1	145
X-ray tubes	75.5	70.5	81.2	158.6	170.9	195.2	218.4	237.9	259.2	275
Parts for X-ray equipment	24.3	16.0	22.0	26.4	50.2	49.1	34.5	67.7	67.8	70
Other irradiation equipment	57.0	82.8	57.4	101.2	94.1	84.1	135.8	177.4	117.6	115
TOTAL	3380.4	4402.1	4844.7	5148.1	5027.7	5,111.1	5,575.6	6,014.9	6,910.8	7,480

[1] Dialyzers included in "Other therapeutic equipment" prior to 1980.

[2] Included in "other diagnostic equipment."

r-Revised.

e-Estimated by EIA Marketing Services Department.

na-Not available.

SOURCE: U.S. Department of Commerce.

Diagnostic Equipment

U.S factory shipments of diagnostic equipment totaled $2.7 billion in 1990. up 7.9% fron $2.5 billion in 1989. Advances in microelectronics technology have resulted in increased electronics applications of diagnostic equipment. The use of computers has enhanced the speed. image clarity. and analytical capabilities of medical imaging equipment and other medical devices. Many new products are now in use or under development. such as nuclear magnetic resonance imaging devices.

Frequently. complex. technology-intensive devices are relatively easy to use because of built-in features for operation. safety. self-calibration. fault diagnosis. and repair. Many raise productivity in the delivery of health care services and reduce unit costs.

Digital radiography is a newly developed computerized system which is intended to enhance and manipulate X-ray information coming from existing X-ray equipment. Initially well-received by the medical community. digital radiography is now experiencing problems. Installed systems have not yielded the results physicians anticipated. Digital radiography's second generation integrates digital X-ray systems with all-new X-ray equipment and the computer image-processing system.

Conventional X-ray is still the world's dominant imaging technique and is projected to remain so into the 1990s. However. total market share is less that it once was. and more that what it will be. due to the continuous introduction of more advanced modalities. the market researcher Predicasts reports.

The next-largest technology group is composed of computerized axial tomography (CAT) devices. CAT scanners experienced phenomenal growth in the late 1970s. but the growth rate has declined recently due to competition from nuclear magnetic resonance (NMR). and position emission tomography (PET).

CAT scanners work by taking narrow-beam X-ray slices of an organ such as the brain or heart and. with the help of computers. combining the information from each slice into a composite image that has resolution much higher than that possible with conventional X-ray equipment. The devices cost in the range of $700,000 to $1.2 million. a price often too steep for facilities other than major medical teaching institutions and city hospitals. Less expensive CAT equipment. costing form $400,000 to $800,000. is coming on the market. but it has limited capabilities.

While CAT scanners have worked medical miracles for many patients. industry observers predict that NMR. used for diagnosis and monitoring of diseases. will continue to lead the medical imaging field. NMR can detect small changes in the body's use of energy that could help determine whether a tumor is malignant. With technological advances. it might also be used to diagnose conditions that could eventually lead to heart attacks or strokes. A radiologist's dream come true. NMR can take images of the body's interior—similar to those from CAT scanners—without using ionizing radiation. such as X-rays.

Metabolic changes in the body often occur before any change in anatomy can be picked up by X-ray. Theoretically. NMR could identify malignancies at their modular start. and patients could be treated immediately with chemotherapy before their diseases require surgery.

Imports and Exports of Industrial Electronic Equipment by Type, ($ Million); United States, 1989-1990

TABLE 3-10

	1989	1990
IMPORTS		
Cash Registers and Adding Machines	344	295
Copying Machines and Parts	2.335	2,232
Data Processing Machines and Parts	20.781	22.213
Dictation Machines	19	25
Alarms and Smoke Detectors	160	143
Other Indicators and Signalling Apparatus	723	687
Industrial Robots and Parts	181	121
Ferrite Core Memories	22	11
Electron and Proton Microscopes	66	51
Electromedical Equipment (Excludes X-ray and Radiation)	961	1.150
X-ray Equipment	553	622
Other Radiation Equipment	164	171
Nuclear Apparatus	71	79
Automatic Flight Control Instruments	26	26
Geophysical Instruments	103	105
Liquid and Gas Measuring Equipment	604	700
Physical and Chemical Analysis Equipment	485	513
Electrical Properties Measuring Equipment	470	364
Other Test. Measurement and Control Equipment	3.825	2,981
TOTAL	31.893	32.489
EXPORTS		
Accounting Machines and Parts	80	114
Analog and Hybrid Data Processing Equipment	308	289
Digital Data Processing Equipment	2.505	2,264
Digital Central Processing Units	4.547	5,396
Random Access Peripheral Storage Units	2.354	2.742
Serial Access Peripheral Storage Units	601	815
Point-of-Sale Terminals	63	90
Other Terminals	1,014	1,093
Card Key Magnetic Media Entry Devices	52	29
Optical Scanner Devices	167	175
DP Printers	748	1,035
Other Data Processing Equipment and Parts	11.791	12.429
Numerical Controls for Machine Tools	41	29
Copying Machines (Direct, Indirect, Photocopy)	750	895
Traffic Control Devices	41	49
Electronic Indicator Panels (LED and LCD)	37	46
Alarms and Other Sound Equipment	213	263
Signal Generators	135	133
Motor Vehicle Signal Equipment	106	128
Electromedical Equipment	1,681	1,876
X-ray Equipment	385	511
Nuclear Apparatus	147	142
Navigational Instruments	714	770
Geophysical Meteorological, Hydrological Instruments	566	655
Physical Properties Equipment	438	467
Temperature Measurement Equipment	59	59
Industrial Process Control Equipment	414	462
Chemical Analysis Equipment	725	763
Physical Analysis Equipment	559	687
Radiation Detection and Measuring Equipment and Parts	191	201
Circuit Analysis Equipment	1,288	1,232
Oscilloscopes and Wave Measuring Equipment	176	169
Electrical Quantities Measuring Equipment	706	716
Other Test. Measuring and Control Equipment	4,213	4,838
TOTAL	37,815	41,562

SOURCE U.S Department of Commerce.

NMR may well surpass CAT in viewing the extent of tumors of soft tissues and bone in the extremities. Diagnosing tumors involving the hilum or the mediastinum is difficult with CAT, as blood vessels can be confused with tumors. This is not the case with NMR. NMR also appears to have advantages both over CAT in detecting neurological disorders, and over ultrasound for breast scanning.

Positron emission tomography (PET) offers a promising diagnostic imaging technique. PET is capable of detecting very small biochemical changes and is far more sensitive than X-ray and CAT scanners. The limiting factor in PET technology is the need for a cyclotron capable of producing the shortlived isotopes utilized in the process. Future development of a "table-top" cyclotron or positron emitter, along with other refinements in the radiochemistry, will have a positive impact on the market.

Therapeutic Equipment

U.S. shipments of therapeutic equipment reached an estimated $1.3 billion in 1990, up 7.4% from the 1989 level of $1.2 billion (Table 3-9). The most rapid growth of revenue from therapeutic devices has occurred in the areas of electrical stimulation (used for pain control), neuromuscular rehabilitation, and laser surgery. The number of participants in this highly competitive market is expected to decline slightly over the next several years as major shakeouts occur in the pacemaker and dialysis manufacturing segments.

Shipment of stimulators such as the transcutaneous electrical nerve stimulation (TENS) units are expected to do well in the therapeutic equipment market. TENS is the major form of therapy used in many comprehensive pain treatment programs. Industry experts predict that TENS units will eventually be used in half of the surgical operations associated with post-operative pain. The therapeutic use of TENS involves placing electrodes at various locations of the body and then applying electrical impulses to the patient through the electrodes.

Microprocessors and microcomputers are playing an increasingly important role in all phases of pacemaker therapy. Such technology is responsible for more than half of the significant advances in cardiac pacing.

As pacemaker complexity increases, interest in advancing the pacemaker analyzer (PSA), and other measurement devices that can communicate directly with an external mainframe computer or microcomputer used for data acquisition, database management, and reporting, is on the rise. A PSA is a battery-powered, microcomputer-based device used during lead implantation to evaluate the threshold of stimulation and amplitude of signals sensed through the pacing lead. This technology is especially important in pacemaker follow-up, when the availability of complete and accurate data can be

Factory Shipments of Other Electronic Systems and Equipment, Not Elsewhere Classified, ($ Million); United States, 1981-1990

TABLE 3-11

	1981	1982	1983	1984	1985	1986	1987	1988^r	1989^r	1990^e
Amplifiers (except audio, RF power and video)	42.9	55.1	57.6	62.4	53.0	20.1	39.5	37.2	27.9	25
Electronic games: arcade (except coin-operated) Includes home types prior to 1982.	1,037.3	919.9	479.9	283.7	159.8	180.1	258.8	192.4	278.1	285
Automatic garage door openers, electronic	146.7	137.3	186.9	197.8	184.4	202.9	232.7	264.6	254.9	250
Ultrasonic equipment: cleaners, drills, solderers and welders	80.6	86.4	107.0	127.2	114.2	136.5	93.5	101.3	107.5	120
Trainers and simulators	514.7	622.1	770.7	766.9	895.1	969.7	1,112.5	1,156.4	956.5	910
Teaching machines and teaching aids	81.4	87.2	21.3	64.3	66.9	34.8	50.6	87.2	116.6	150
Particle accelerator electronic equipment	25.6	47.4	33.9	29.1	19.4	14.8	26.2	26.6	15.4	20
Scientific electronic equipment, n.e.c.	188.4	211.2	184.8	186.9	120.7	115.9	143.7	126.3	125.8	125
Laser systems and equipment, except communication	586.2	507.8	545.2	622.8	684.5	766.0	879.3	894.7	908.1	925
Electronic kits to be assembled by purchaser including computers, receivers, transceivers, transmitter-receivers, amateur equipment, and test and measuring equipment	211.3	292.1	193.8	278.8	na	na	22.5	na	na	na
Other electronic systems, equipment and subassemblies, n.e.c.	953.1	902.5	831.3	886.4	1,072.9	1,040.2	937.7	938.4	963.3	990
TOTAL^r	3,868.2	3,869.0	3,412.4	3,506.3	3,370.9	3,481.0	3,797.0	3,825.1	3,754.1	3,800

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

very important in solving pacing problems through noninvasive programming rather than surgical intervention.

State-of-the-art electronics is also being used to help the hearing impaired. Recently, instrumentation has been developed to effectively provide high-frequency amplification and allow the user to amplify sounds in selected frequency ranges. A microcomputer-based system for tuning an experimental hearing aid has been created. The computer adjusts the frequency range response to the patients hearing defect as revealed by audiologic data. Adjustments may be made for the tunable parameters of the hearing aid itself, the patient's discomfort level, hearing threshold, and the noise floor in the tuning process. When perfected, such systems are expected to improve the "auditory fit" of modern hearing aids to a patient's hearing loss.

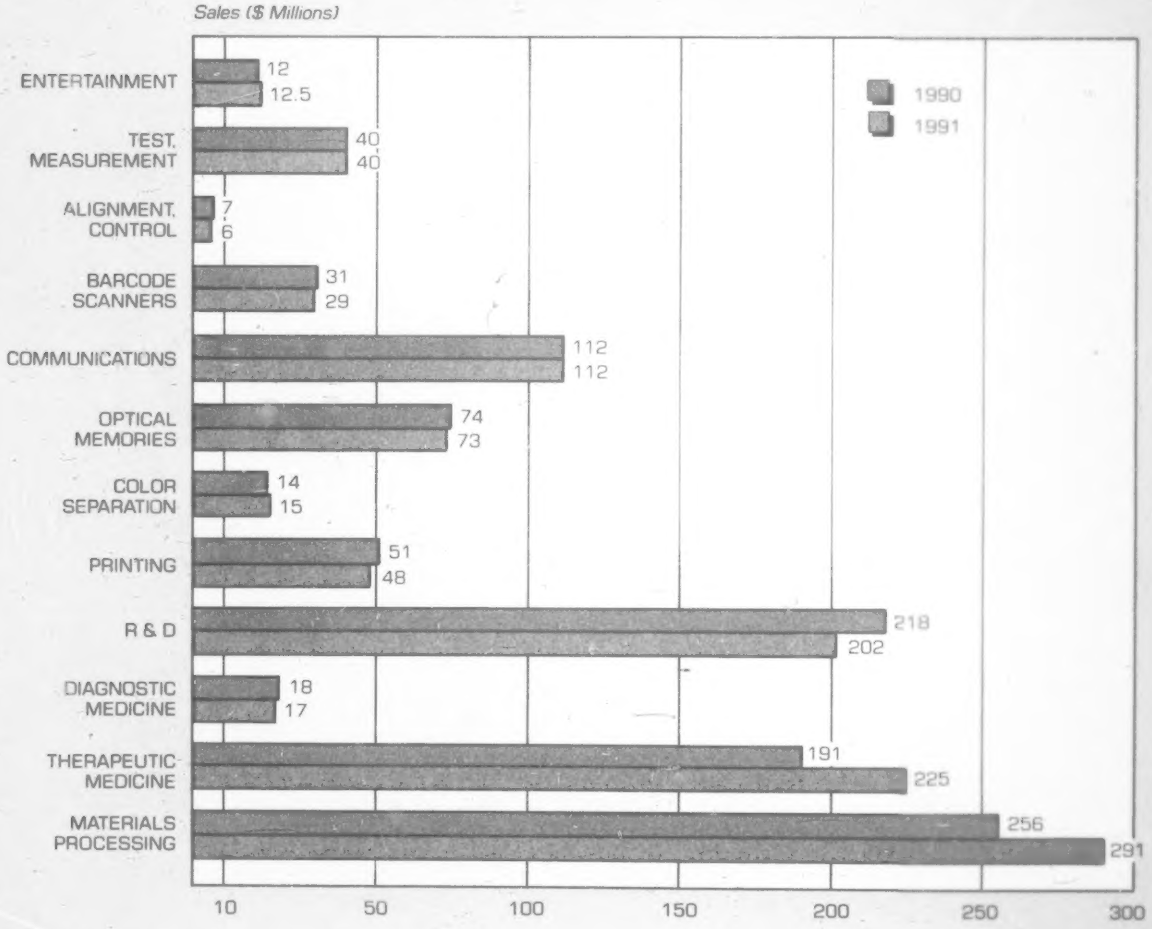
Surgical and Medical Instruments

Within the surgical and operating room instrument market, analysts see laser systems as the area of highest growth, largely because of expanding applications for systems such as laser scalpels and laser surgical "welding" devices. This section highlights medical laser systems, as most surgical and medical instruments are non-electronic.

U.S. factory sales of laser devices for therapeutic and diagnostic medicine are projected to increase to $225 million in 1991, from $191 million in 1990, according to the *Laser Report*.

During the past several years, a steady stream of medical reports has shown successful results for laser surgery in a variety of operations. So far, there are three main laser types:

Laser Device Sales By Application, 1990-1991 **FIGURE 3-E**



SOURCE: Annual Economic Report, *Laser Report*.

Commercial Laser Device Sales by Type, 1984-1990 ($ Million) **TABLE 3-12**

Laser Type	1984	1985	1986	1987	1988	1989	1990
Carbon dioxide	89	110	110	120	155	180	224
Solid-state	82	96	85	89	144	165	219
Ion	71	85	86	88	146	170	148
Diode	53	90	121	179	180	210	250
He-Ne	38	42	44	49	52	60	68
Dye	23	28	31	17	39	44	51
Excimer	14	19	19	22	24	29	34
He-Cd	4	5	6	6	13	18	19
Metal-vapor	na	na	na	na	6	7	12
TOTAL	374	475	502	570	759	883	1,025

na-Not available.
SOURCE: Annual Economic Report, *Laser Report.*

the carbon-dioxide (CO_2) laser, used for precise cutting in general surgery; the YAG laser, used for penetrating tissue, coagulating bulky tumors, and stopping bleeding; and the argon laser, used to vaporize superficial lesions, such as port-wine stain on the skin.

Some applications for lasers in therapy seem extremely promising. For example, doctors are using the CO_2 laser to remove tumors in the brain and the spinal cord. The YAG laser has proven successful for bladder tumors (even in the bladder wall); bleeding ulcers of the stomach and small intestine; and, on the frontier, cancer in patients whose tumors block passageways to the lungs or stomach, impairing breathing and swallowing.

Patient Monitoring Equipment

The patient monitoring equipment industry has become highly computer-oriented. According to estimates based on U.S. government data, U.S. shipments of patient monitoring equipment reached $779 million in 1990, up 7.2% from $727 million in 1989 (Table 3-9).

Patient monitoring equipment is used in the operating room, in intensive and coronary care units, at patients' bedsides, for athletic training, and even for home exercise programs. This equipment will continuously monitor an individual's body temperature, heart rate, respiratory rate, and blood pressure.

Consumer Medical Electronics

As the U.S. population ages and legislators seek better methods of bringing health care costs under control, home health care appears to be an increasingly attractive alternative. According to a study by Predicasts, the total U.S. home health care market for both products and services could reach $24.8 billion by 1995.

Analysts estimate that more than a million Americans are using home computers for health, exercise, and diet monitoring. The consumer medical electronics market is considered one of the highest growth areas for electromedical devices. Because of current trends toward preventative medicine and self-care, some observers believe that in the not so distant future, consumers will be spending nearly $500 million a year on electronic medical devices such as electronic blood pressure machines, thermometers, pulse rate monitors, birth control devices, and computer software. Software packages for determining life expectancy based on an individual's alcohol consumption, weight, diet, exercise, and degree of hypertension may soon be available for home computers.

Today, the hospital computer industry is in the midst of dynamic change and growth. The next decade will see the computer become the most significant instrument in hospital management, and ultimately, in the delivery of health care itself. The next few years of this rapid evolution will be critical, both for hospitals purchasing or expanding health care computing systems and for systems manufacturers.

4

Electronics Components

U.S. factory sales of electronic components totaled $55.2 billion in 1990, up 0.5% compared to sales of $54.9 billion in 1989 (Table 4-1). Electronic components are fundamental to the construction of every electronic product—from consumer electronics products such as laser disc players and camcorders, to military instruments such as the Patriot missile. In fact, the military is one of the largest users of electronic systems—for radar for search and detection equipment, and for navigation and guidance systems.

Components are classified as either "active" or "passive." Semiconductors, the largest segment of active components, amplify or modulate electrical signals, or rapidly switch voltages or currents to generate signals that can be stored (memory), added to, or subtracted from other signals (logic), and then transmitted. A cathode ray tube, a vacuum display tube in which an electron beam strikes a phosphor screen and causes it to glow, is also considered an active component.

Passive components, often referred to as electronic parts, do not contribute to the electrical signals, but simply carry them from one active component to another (wire and cable connectors); or turn them on or off (switches and relays); or tune electrical circuits (capacitors and coils); raise or lower voltages (transformers), or limit current flows (resistors).

In 1990, U.S. factory sales of active components reached $24.5 billion—with semiconductors accounting for $22 billion. Passive components factory sales in 1990 were $10.2 billion. Active and passive components combined accounted for 13% of total U.S. electronic factory sales in 1990. Besides active and passive, there are a number of miscellaneous components not usually considered either active or passive (see "Other Components," Table 4-1).

The major technological trends in the electronic components area continue to be miniaturization and the move toward surface-mount technology (SMT) and surface-mount devices (SMD). SMT contributes to a 30 to 40 percent reduction in the size and weight of the component. SMT calls for connecting specially designed electronic components to electrical circuits by soldering them directly to the copper traces or wiring pathways laid out on printed-circuit boards, rather than by mounting them on a board and then soldering the leads to traces on the underside of the board.

According to the Market Intelligence Research Company, the SMT manufacturing equipment business is in the strong growth phase of its life cycle. Strong growth in virtually every subsegment is expected to result in a compound annual growth rate of 24.3% over the period 1989-1996, and the total 1996 world market is forecast to be $4.6 billion.

Assembly time may be cut 80% or more by using surface-mount devices (SMD), and the assembly process may be almost completely automated. SMDs are much smaller than leaded components and therefore will fit on smaller boards. Driven by high-volume categories, such as multi-layer ceramic and tantalum chip capacitors, surface-mount passive devices generally average 15-20% annual growth rates according to Ralph Anavy, Electronic Outlook Corp. Ceramic capacitors and tantalum are two of the largest passive component products categories in the North American market.

For the past six years, the Electronic Industries Association has co-sponsored, along with the Institute for Interconnecting and Packaging Electronic Circuits (IPC), the annual Surface Mount and Advanced Related Technology (SMART) conference. These conferences have reviewed the latest technological and standardization issues facing the electronic industry. Recently, the EIA and the IPC merged SMART with another surface mount show and conference owned by the Surface Mount Technology Association and Miller Freeman Exposition Company to form Surface Mount International Exposition and Conference which will be a more comprehensive show and conference for engineering executives involved with SMT. The first Surface Mount International will be held August 1991 in San Jose, California.

The balance of trade for electronic components continued to be negative in 1990. With exports of active and passive components totaling $20.7 billion and imports totaling $21.6 billion, the difference was a negative $929 million—which represents less than 2% of total U.S. factory sales. The trade deficit declined by 76% in 1990, from the 1989 deficit of $3.8 billion. The trade picture continued to reflect strong import penetration from Japanese suppliers and heavy offshore assembly operations by American firms. It is hoped that the improvement in the trade deficit in 1991 over 1990 may be partially attributable to the U.S.-Japanese anti-dumping agreement on semi-conductors, and the strengthening of the Japanese yen in comparison with the dollar.

According to the *U.S. Industrial Outlook '90*, the value of component shipments is expected to increase 6.6% in 1991. It is generally agreed that the decline in GNP and the Gulf War have inhibited capital outlays, which in turn have stunted the demand for components. However, many forecasts are citing strong growth in 1991.

Factory Sales of Electronic Components (\$ Million); United States, 1981-1990

TABLE 4-1

DESCRIPTION	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ELECTRON TUBES										
Receiving Tubes	100	76	62	36	32	30	28	25	10	5
Power & Special Purpose Tubes	858	925	1,007	1,059	1,061	1,067	1,119	1,171^r	1,075^r	1,040
TV Tubes	1,001	884	980	1,042	962	1,028	1,029	1,093	1,511	1,529
TOTAL-Electron Tubes	1,959	1,885	2,049	2,137	2,055	2,125	2,176	2,289^r	2,596^r	2,574
SOLID STATE-PRODUCTS										
Transistors	638	597	626	824	655	688	753	864^r	829^r	780^e
Diodes and Rectifiers	782	655	736	761	755	686	780	855^r	794^r	715^e
Integrated Circuits	6,976	7,322	8,861	12,960	10,806	10,816	12,851	14,865^r	16,000^r	15,465^e
Other Semiconductors	1,913	2,155	2,347	2,487	2,434	2,220	2,436	3,206^r	4,753^r	4,980^e
TOTAL-Solid State Products	10,309	10,729	12,570	17,032	14,650	14,408	16,819	19,790^r	22,376^r	21,950^e
PARTS										
Capacitors	1,297	1,169	1,277	1,619	1,200	1,223	1,411	1,533	1,536^r	1,412
Resistors[1]	636	583	638	698	587	586	658	682	717	757
Passive Networks	139	138	153	226	193	159	168	181	186	180
Coils and Transformers	952	842	966	1,055	1,179	1,042	1,149	1,183^r	1,164^r	1,060^e
Connectors	2,203	2,148	2,586	3,200	2,901	3,026	3,629	3,748^r	3,449^r	3,275^e
Switches	377	446	512	548	577	537	692	625^r	633^r	635^e
Filters	124	142	167	232	178	210	233	190^r	181^r	170^e
Quartz Devices	413	266	257	340	338	319	395	381^r	249^r	235^e
Wire and Cable	1,176	1,304	1,386	1,613	1,475	1,409	1,662	1,772^r	1,904^r	1,980^e
Relays[1]	245	282	296	552	631	588	596	507^r	478^r	460^e
TV & FM Antennas and Parts	85	83	80	72	72	76	71	69	63	61
TOTAL-Parts	7,647	7,403	8,318	10,155	9,331	9,175	10,664	10,871^r	10,560^r	10,225^e
OTHER COMPONENTS[2]	8,869	9,544	10,919	13,982	13,423	13,121	15,676	18,038^r	19,405^r	20,415^e
GRAND TOTAL	28,784	29,561	33,856	43,306	39,459	38,829	45,335	50,988^r	54,937^r	55,164^e

[1] U.S. consumption

[2] Includes sockets, delay lines, loudspeakers, magnetic components, transducers, printed circuit boards, microwave components, other components, assemblies and parts.

r-Revised

e-Estimated

SOURCES: EIA Marketing Services Department, U.S. Department of Commerce.

ELECTRON TUBES

Factory sales of electron tubes totaled \$2.6 billion in 1990, down 0.9% from 1989. The most widely used type of electron tube in the United States is the cathode ray television picture tube, which accounted for almost 60% of all factory sales of tubes. Other types of cathode ray tubes (CRTs) are those used as the screen for computers and as the display for oscilloscopes and other testing and measuring devices. Sales of microwave tubes, used in radar and telecommunications, accounted for about 17% of total tube industry sales. Other types of tubes include high vacuum, gas and vapor, and special purpose tubes and various other electro-optical devices. Receiving tubes (so named because they were the "vacuum tubes" in old-time radio receiving sets) have almost disappeared, having been replaced by semiconductors. Factory sales of receiving tubes were only \$5 million, down from \$10 million last year, continuing the steady decline since 1981.

In 1990, the balance of trade in electron tubes was a negative \$45.3 million, a 73% reduction from the 1989 trade deficit. Imports decreased 4% in 1990 to \$821.8 million. Meanwhile, exports increased 13% over 1989, reaching \$776.5 million.

Sales of electron tubes are expected to increase over the next several years, with military consumption and TV manufacturers' needs for additional picture tubes accounting for this increase. While semiconductors continue to replace some categories of tubes, they cannot replace CRTs, and so far they cannot generate the power required for such microwave tube applications as long-range radar and communications systems.

Television Picture Tubes

Factory sales of TV picture tubes were placed at 14.4 million units in 1990, down 5% over 1989 (Table 4-2). The average price of a picture tube increased 6%, from \$100 in 1989 to \$106 in 1990. Dollar sales of TV picture tubes are estimated to have increased a slight 1.2% in 1990, to a reported \$1.5 billion.

Color tubes accounted for nearly all of factory TV tube sales in 1990 in units and dollars. Exports accounted for 15% of unit sales of color TV tubes in 1990, as compared with 11% in 1989.

All sales of monochrome (black-and-white) tubes were for export. Exports are estimated to have almost doubled in 1990, reaching 54.1 thousand units. In dollars, the estimated increase was 96%, from $2.2 million in 1989 to $4.3 million in 1990.

The dominant technological development in the industry will be flat-screen displays and High Definition Television (HDTV), currently being worked on by U.S., European, Korean, and Japanese manufacturers.

The three most widely manufactured flat-panel displays include active-matrix LCD, plasma, and electroluminescence, and all were invented in the U.S. According to Stanford Resources, the worldwide market is currently $3.8 billion. The active-matrix display, which is used on many laptop computers, consists of two sheets of polarizing material with a layer of liquid crystal solution between them. Active-matrix displays have a transistor for each pixel: when the transistor is turned on, it causes the crystal to twist, allowing light to emanate through it. Stanford Resources forecasts total flat panel display sales to increase from 1.46 million units in 1989 to 9.9 million units in 1996.

Receiving Tubes

Factory sales of receiving tubes totalled an estimated $5 million in 1990, down from sales of $10 million the previous year and from $100 million about ten years ago (Table 4-4). Receiving tubes, so named because they were the vacuum tubes used in old-time receiving sets, have almost disappeared, having been replaced largely by semiconductors. Tubes produced today are mainly for replacement purposes.

Power and Special-Purpose Tubes

Sales of power, transmitter, and special-purpose tubes are estimated at $1.04 billion in 1990, down about 3% from 1989 (Table 4-5).

Microwave tubes accounted for 38% of all power, transmitter, and special-tube sales—and over 63% of these were traveling wave tubes, which are mostly used in defense. Electro-optical tubes, including cathode ray tubes other than TV picture tubes, accounted for 44% of these sales. The balance were high-vacuum, gas and vapor, and special purpose tubes, such as vacuum capacitors, switches & relays, radiation detection tubes, and miscellaneous special purpose tubes.

The government market constitutes a large share of the power and special purpose tube business, and declining defense budgets are expected to have a negative impact.

High-Vacuum, Gas & Vapor and Special-Purpose Tubes

Factory sales of high-vacuum, gas and vapor, and special-purpose tubes are estimated at $189 million in 1990, down 3% from 1989's $194 million (Table 4-5). This decline was influenced by a decline in sales of high vacuum tubes.

Essentially, these tubes are power tubes used in radio frequency applications, with the military being one of the largest users. They include diodes, triodes, thyratrons, ignitrons, and related types of tubes. Power tubes are being phased out as the capacity of power semiconductors increases. As a consequence, the market is largely one of spares and replacements.

Factory Sales of Television Picture Tubes by Screen Size (Thousands of Units and Dollars); United States, 1981-1990[1] **TABLE 4-2**

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Color Units										
12" & Under	181.1	123.4	*	*	*	11,684.3	12,229.4	13,747.4	15,027.2	14,312.6
13"		948.2	1,199.1	1,646.5	911.6					
14"	1,144.4	13.0	169.6	172.5	77.9					
15"			32.5	42.0	9.3					
16"			.3	—						
17"	347.2	293.0	156.0	105.3	30.8					
18"			.7	3.8	3.4					
19"	6,080.7	5,485.0	6,306.4	6,423.0	6,095.0					
20"			6.8	1.3						
21"	492.4	198.7								
22" and 23"		941.3	94.0	43.8						
24" and 25"	2,840.8	1,932.7	3,443.2	3,956.1	4,193.3					
26" and Over			155.9	350.9						
TOTAL (Units)	11,086.6	9,936.3	11,564.5	12,745.2	11,321.3	11,684.3	12,229.4	13,747.4	15,027.2	14,312.6
TOTAL (Dollars)	$998,7[illegible]	$883,704	$978,854	$1,041,374	$961,405	$1,026,687	$1,026,409	$1,088,912	$1,508,595	$1,524,590
Monochrome[2]										
TOTAL (Units)	40.9	7.4	10.3	20.0	5.6	16.4	66.4	89.8	28.4	54.1
TOTAL (Dollars)	$2,404	$585	$976	$629	$475	$1,109	$2,624	$4,224	$2,249	$4,327
GRAND TOTAL (Units)	11,127.5	9,943.7	11,574.8	12,765.2	11,326.9	11,700.7	12,295.8	13,837.2	15,055.6	14,366.7
GRAND TOTAL (Dollars)	$1,001,110	$884,289	$979,730	$1,042,003	$961,880	$1,027,796	$1,029,033	$1,093,136	$1,510,844	$1,528,917

[1] Excludes imports and sales by non-reporting rebuilders. Data subsequent to 1985 exclude all renewal equipment.
[2] Data exclude initial equipment.
*Included in 14"
SOURCE: EIA Marketing Services Department, U.S. Dept. of Commerce.

Factory Sales of Television Picture Tubes by Market (Thousands of Units and Dollars); United States, 1981-1990[1]

TABLE 4-3

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Color Units										
Initial Equipment	10,048.1	9,274.6	10,737.0	11,975.0	10,719.8	10,810.2	11,716.3	12,152.8	13,387.7	12,114.9
Renewal	362.8	354.7	337.4	312.2	285.9	na	na	na	na	na
Export	675.7	307.0	490.1	458.0	315.6	874.1	513.1	1,594.6	1,639.5	2,197.7
TOTAL (Units)	11,086.6	9,936.3	11,564.5	12,745.2	11,321.3	11,684.3	12,229.4	13,747.4	15,027.2	14,312.6
TOTAL (Dollars)	$998,706	$883,704	$978,854	$1,041,374	$961,405	$1,026,687	$1,026,409	$1,088,912	$1,508,595	$1,524,590
Monochrome Units										
Initial Equipment	—	—	—	—	—	—	—	—	—	—
Renewal	15.9	na	na	na	na	na	na	na	na	na
Export	25.0	7.4	10.3	20.0	5.6	16.4	66.4	89.8	28.4	54.1
TOTAL (Units)	40.9	7.4	10.3	20.0	5.6	16.4	66.4	89.8	28.4	54.1
TOTAL (Dollars)	$2,404	$585	$876	$629	$475	$1,109	$2,624	$4,224	$2,249	$4,327
GRAND TOTAL (Units)	11,127.5	9,943.7	11,574.8	12,765.2	11,326.9	11,700.7	12,295.8	13,837.2	15,055.6	14,366.7
GRAND TOTAL (Dollars)	$1,001,110	$884,289	$979,730	$1,042,003	$961,880	$1,027,796	$1,029,033	$1,093,136	$1,510,844	$1,528,917

[1] Excludes imports and sales by non-reporting rebuilders.
na-Not Available.
SOURCE: EIA Marketing Services Department, U.S. Dept. of Commerce.

which will shrink as equipment now in use is replaced by solid-state equipment. However, power tubes still find applications in industrial heating equipment and in FM transmitters: both markets expected to experience moderate growth.

Sales of high-vacuum tubes—diodes, triodes, and multigrid external anodes, UHF planars and pencils, and multi-grid internal anodes—declined 4%—from $111 million in 1989 to $107 million in 1990. Sales of gas and vapor tubes—diodes, thyratrons, ignitrons, gas duplexers, spark gaps, and noise sources—declined slightly to $37 million. Sales of special-purpose tubes, estimated at $45 million in 1990, were up 7% from 1989. This category includes radiation detection tubes, vacuum capacitors, switches & relays, and other types of special purpose tubes.

Imports of diodes, triode and tetrode and gas and vapor tubes increased substantially from $9.5 million in 1989 to $11.3 million in 1990. Exports of these products, however, fell from $46.4 million in 1989 to $45.6 million in 1990.

The outlook is for unit sales of these power tubes to gradually decline. Estimates gathered by the EIA show that overall dollar sales will decline about 3% a year in real terms through 1994.

Electro-Optical Devices

Factory sales of electro-optical devices are estimated to have totalled $457 million in 1990, up 2.2% over 1989 sales (Table 4-5). The slight increase was due mainly to sales of image intensifiers and converters and special display devices.

During 1990, sales of photo-emissive and photo-conductive camera tubes and image intensifiers and converters claimed over 50% of total dollar sales of electro-optical devices. Industrial and military (I&M) CRTs, storage and display/monitor tubes accounted for 17% of sales, while photomultipliers, photo cells, and other photo tubes and devices accounted for 30% of total electro-optical device sales.

According to the EIA, there will be an increase in the photomultiplier tube sales for the next 1 to 3 years, assuming the FAA succeeds in requiring bomb detectors in all major airports. The market for photoemissive cameras will continue to decline as solid state cameras continue to gain market share. Further improvements in solid state sensors in the areas of noise reduction and signal processing will make operation at lower light levels possible, reducing the need for intensification.

The market for special purpose I&M cathode ray tubes will increase less than 10% during the next five years; however, flat panel displays will begin to gain market share. Cathode ray tubes are still advantageous in the areas of resolution,

Factory Sales of Receiving Tubes (Thousands of Units and Dollars); United States, 1981-1990

TABLE 4-4

YEAR	UNITS	DOLLAR VALUE[1]
1981	29,843	100,345
1982	21,411	75,581
1983	14,495	61,604
1984	8,364	35,714
1985	7,861	31,916
1986	na	30,000
1987	na	28,000
1988	na	25,000
1989	na	10,000
1990	na	5,000

[1] Value estimated.
na-Not available.
*Included in Government Sales.
SOURCE: EIA Marketing Services Department.

Sales[1] of Power and Special Purpose Tubes ($ Million); United States, 1981-1990

TABLE 4-5

CATEGORY	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
High vacuum tubes	119	122	126	135	114	112	113	122	111	107
Gas and vapor tubes	40	32	32	40	33	41	42	42	41	37
Klystrons	89	104	111	103	92	84	74	76	65	62
Magnetrons/CFAs	72	83	92	85	77	78	85	100	80	82
Forward and backward wave tubes	166	233	271	289	319	347	383	343	289	250
Electro-Optical devices[2]	337	314	330	357	371	345	368	445[r]	447[r]	457
Miscellaneous[3]	35	37	45	50	55	60	54	43	42	45
TOTAL	858	925	1,007	1,059	1,061	1,067	1,119	1,171[r]	1,075[r]	1,040

[1] Excludes R&D Billing.
[2] Excludes entertainment TV picture tubes.
[3] Includes radiation detection tubes, reference cavities, beam deflection tubes, decade counters, mechanical transducers, orbital beam tubes, and vacuum capacitors, switches and relays.
r-Revised.
SOURCE: EIA Marketing Services Department.

brightness and full color capability. Laser systems will continue to grow in the markets for monochrome displays and electronic recording for medical records and typesetting.

Microwave Tubes

U.S. factory sales of microwave tubes, including klystrons, magnetrons, CFAs and forward & backward wave tubes totaled $394 million in 1990, down 10.2% from 1989 sales of $434 million (Table 4-5).

Microwave tubes find their primary applications in high and ultrahigh frequency applications—especially radar and communications systems. In the last nine years, the U.S. microwave tube industry has expanded its floor space by 25%. There is excess capacity and a lack of planning information. Difficult times will continue for the next 2 to 3 years. As defense spending declines, a trend toward non-defense applications will be pursued.

Sales of traveling-wave tubes (TWTs) and backward-wave oscillators (BWOs) totalled $250 million in 1990, down over 13% from 1989. Continuous-wave TWTs accounted for $116 million; pulsed TWTs accounted for $127 million; and BWOs $7 million. Sales of klystrons totaled $62 million in 1990, down 5%. Sales of magnetrons and cross-field amplifiers (CFAs) increased slightly to $82 million in 1990.

The biggest single market for microwave tubes is radar systems, both airborne (including missiles) and surface and shipboard. The next largest market is for electronic countermeasures (ECM), including decoys and related equipment, which will grow and provide a positive stimulus to the microwave tube sector. However, this force will be somewhat offset by the growing use of solid state products. Some of the major systems using radar systems incorporating TWTs are MILSTAR, NESP, Aegis, Patriot, and AMRAAM. ECM applications include ASPJ and ALQ-162. TWTs for ECM applications will account for approximately 35% of all TWT production, while TWTs account for two-thirds of all microwave tube shipments. The trend in TWTs is toward low-cost tubes, directed beam systems in EW, distributed antenna arrays and generally lower power, low noise devices with broad bands.

Almost all of the growth is expected to be in TWTs. Sales of magnetrons are estimated to drop 3% over the next four years. (Incidentally, magnetrons are used in microwave ovens, a still-growing field—but all microwave ovens, along with their magnetrons, are foreign supplied[1]). Klystrons used in large high-power radars are increasingly being replaced by solid-state phased-array systems. Increased demand can be expected for klystrons for LINACS, storage rings, isotope separations, and free-electron lasers and fusion, with total sales of klystrons expected to decline about 6%. Sales of BWOs are also expected to decline over the next four years. Sales of cross-field amplifiers, which make up about 41% of the magnetron/CFA category, are expected to rise about 15% from 1989 to 1993.

During 1990, research and development expenditures increased 3.4% to $16.1 million. This was an increase from 3.6% of sales in 1989 to 4.1% in 1990. R & D expenditures are

Balance of Trade of Electron Tubes ($ Million); United States, 1981-1990

TABLE 4-6

YEAR	IMPORTS	EXPORTS	BALANCE OF TRADE
1981	300.0	377.3	+ 77.3
1982	246.1	313.2	+ 67.1
1983	314.7	308.8	− 5.9
1984	396.7	345.8	− 50.9
1985	443.4	368.9	− 74.5
1986	519.7	425.9	− 93.8
1987	473.8	409.9	− 63.9
1988	585.1	604.8	+ 19.7
1989	852.5	685.8	− 166.7
1990	821.8	776.4	− 45.3

SOURCE: U.S. Department of Commerce.

expected to decline very slightly in absolute terms, dropping just below 8% of sales in 1993.

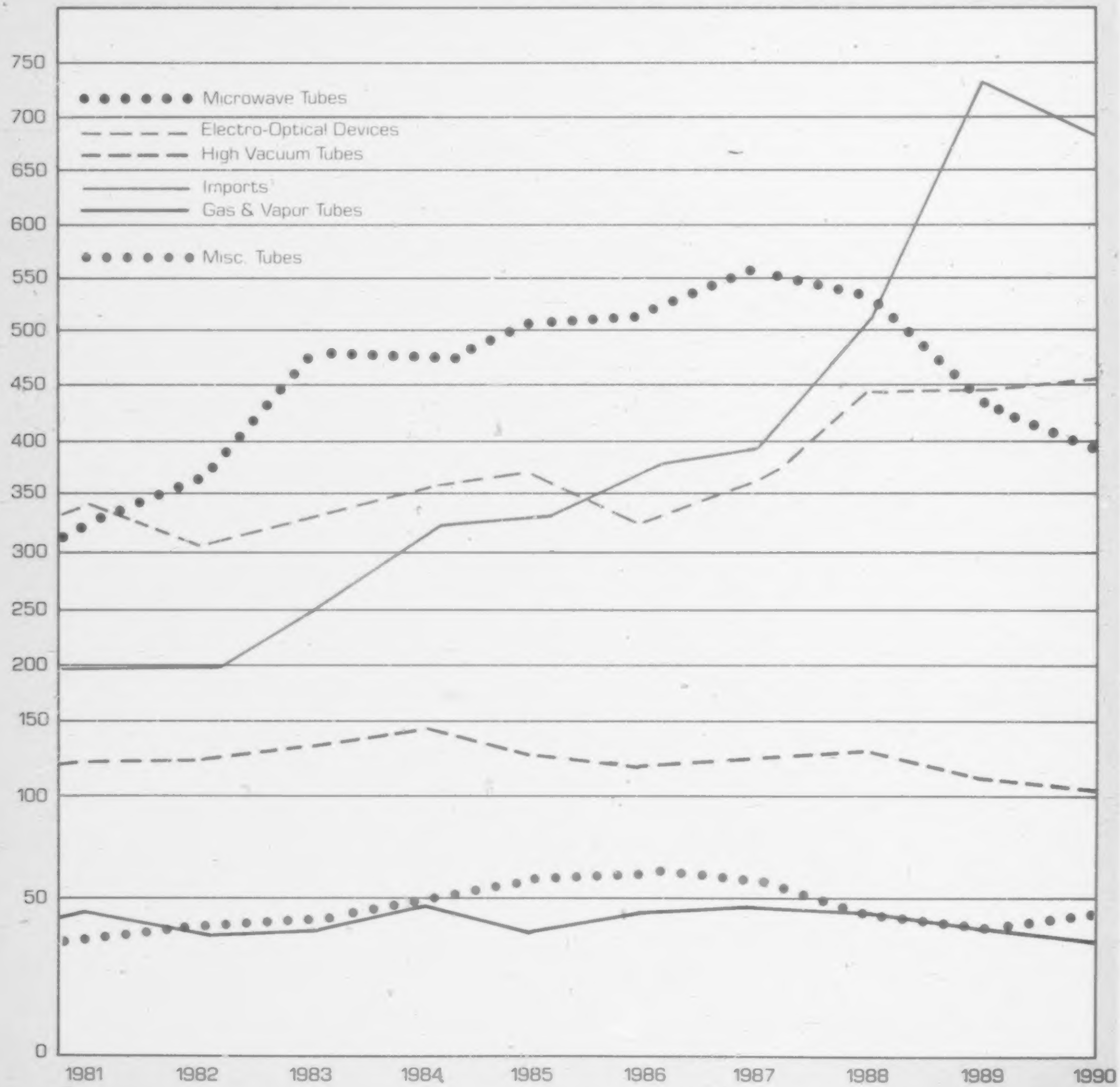
Imports and Exports of Electron Tubes

U.S. exports of electron-tube products reached $776.4 million in 1990—up 13% from 1989 (Table 4-8). Excluding X-ray tubes and parts, exports represented over 26% of sales of electron tubes in 1990, up from 22% in 1989.

The balance of trade deficit in electron tubes was reduced by 73% in 1990, ending the year at $45.3 million.

Imports of TV picture tubes totaled almost $140.4 million, up 13.4% from 1989. Imports of electro-optical tubes, including CRTs but not CRT glass and other parts, totaled $286.8 million, down 11%. Imports of microwave tubes totaled $73.6 million. Imports of receiving tubes dropped 28% to $3.1 mil-

Sales of Power, Transmitter & Special Purpose Tubes by Type ($ Million); United States, 1980-1989 **FIGURE 4-A**



¹Includes X-ray tubes.
SOURCE: EIA Marketing Services Department.

Imports of Electron Tubes ($ Million); United States, 1986-1990 **TABLE 4-7**

	1986	1987	1988	1989	1990
TV Picture Tubes, Color	105.9	62.5	54.7	73.7	72.8
TV Picture Tubes, B/W	2.9	2.1	2.3	1.8	7.6
TV Picture Tubes, Projection	24.2	17.6	22.5	48.3	60.0
Cathode Ray Tubes, N.E.S.	48.1	44.1	122.2	274.0	239.9
Parts of CRTs, including Glass	144.7	148.7	162.9	219.0	214.2
Receiving Tubes	7.2	6.1	5.3	4.3	3.1
Gas and Vapor Tubes	1.0	.2	5.8	1.5	1.3
Diode, triode and Tetrode Tubes	4.0	3.4	6.5	8.0	9.9
Magnetrons[1]	47.0	51.4	50.5	60.7	36.8
Klystrons	5.1	5.6	10.1	9.3	10.1
Other Microwave Tubes	15.2	14.3	9.8	22.7	26.7
Light Sensing Tubes	15.6	14.2	15.3	32.6	34.6
Other Light Tubes (Light Emitting)	24.4	29.0	42.1	15.2	12.3
Parts of Electron Tubes	16.5	11.9	9.9	13.5	10.8
X-Ray Tubes and Parts	57.9	62.7	65.2	68.0	81.7
TOTAL	519.7	473.8	585.1	852.6	821.8

[1] Includes magnetrons for microwaves.
SOURCE: U.S. Department of Commerce.

lion. Imports of high-vacuum, gas, and vapor tubes totaled $11.2 million, up 18% from 1989. Imports of electron tube parts including CRT parts and glass, amounted to $217.3 million, down 3% from a year ago.

Exports of TV picture tubes were $248.4 million, up 48%. Exports of electro-optical tubes, again including CRTs but excluding parts and CRT glass, decreased 9% to $227 million. Exports of microwave tubes increased 10% to $88.4 million, while exports of high-vacuum, gas, and vapor tubes declined 2% to $45.6 million. Exports of other tubes and parts, including CRT glass, totalled $161.4 million in 1990, up 16%.

SOLID-STATE PRODUCTS

Total U.S. factory sales of solid-state products, or semiconductors, reached $22 billion in 1990, down 1.9% from 1989 (Table 4-11).

Solid-state products are categorized as integrated circuits (ICs), discrete (or individual) semiconductors, and "other" semiconductors, including light-sensitive or light-emitting devices. Sales of ICs totaled $15.5 billion in 1990; sales of discretes totaled $1.5 billion; sales of other semiconductors devices came to $5.0 billion.

Exports of Electron Tubes ($ Million); United States, 1986-1990 **TABLE 4-8**

	1986	1987	1988	1989	1990
Receiving Tubes	7.1	5.7	11.9	4.1	5.4
TV Picture Tubes, B/W	1.1	2.6	4.2	2.2	4.3
TV Picture Tubes, Color	44.9	48.8	129.4	165.2	244.1
Cathode Ray Storage Tubes	6.0	6.2	7.3	19.2	26.9
Cathode Ray Tubes, N.E.S.[1]	48.7	50.7	79.2	103.2	86.2
Gas and Vapor Tubes	8.7	8.7	10.7	9.0	6.7
Diodes, Triodes and Tetrodes	33.9	33.2	40.6	37.4	38.9
Photomultiplier Tubes	24.0	25.1	36.9	18.2	16.6
Klystrons	9.0	6.5	9.6	14.7	14.0
Magnetrons	11.2	9.6	10.9	11.6	12.4
Traveling Wave Tubes & BWOS	65.4	52.6	67.6	53.7	62.0
X-Ray Tubes and Parts	29.3	52.1	63.4	108.4	97.5
Electron Tubes, N.E.S.	22.1	16.5	22.5	25.7	37.7
Parts, etc., N.E.S., including CRT Glass	114.5	91.6	110.6	113.2	123.7
TOTAL	425.9	409.9	604.8	685.8	776.4

[1] Includes TV Camera Tubes.
SOURCE: U.S. Department of Commerce.

Imports of Color TV Picture Tubes by Country of Origin (Number of Units and Dollars); United States, 1986-1990 **TABLE 4-9**

	1986		1987		1988		1989		1990	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
United Kingdom	3,508	186,384	—	—	*	*	*	*	*	*
Canada	328,360	21,882,353	217,907	15,537,703	80,119	9,119,409	70,681	9,059,909	2,394	398,520
Taiwan	*	*	41,423	2,033,358	14,383	668,389	15,743	992,477	56,767	2,775,644
Japan	310,881	21,476,449	147,485	31,246,754	94,791	43,200,987	122,301	56,385,184	146,620	53,855,611
Korea	1,494,311	54,206,811	269,226	10,667,313	14,977	934,679	21,885	1,271,305	34,472	3,144,521
Singapore	182,605	8,003,058	46,163	1,916,970	*	*	*	*	2,279	108,661
Brazil	—	—	—	—	—	—	—	—	—	—
Other	1,963	152,856	9,561	1,078,751	3,827	761,593	66,452	6,036,491	119,150	12,552,123
TOTAL	2,321,628	105,907,911	731,765	62,480,849	208,097	54,685,057	297,062	73,745,366	361,682	72,835,080

*Figures for countries with less than 2000 units are included in "Other."
SOURCE: U.S. Department of Commerce.

Discrete Semiconductors

Sales of discrete, or individual, semiconductors totaled $1.5 billion in 1990, down 7.9% from 1989 sales of $1.6 billion.

Discrete semiconductors may be transistors, which can amplify electrical signals, but most often are used as digital switches—turning an electric current on or off. Or they may be diodes or rectifiers, which for the most part are used to convert alternating current, or AC signals, to direct current, or DC signals. Both transistors and diodes may be "signal" devices, which can handle up to half an ampere of current (half a watt, in the case of transistors), or "power" devices, which can handle greater loads.

While there continue to be applications which call for signal transistors and diodes, the trend is to replace these discrete devices with integrated circuits. In contrast, as the current-carrying capacity of power transistors and diodes increases, these discrete devices tend to replace power and special-purpose electronic tubes. One technical development that has become more significant is the use of "on-board" logic circuits to control power semiconductors—resulting in the so-called "smart power circuit."

Integrated Circuits

Factory shipments of integrated microcircuits, usually called just integrated circuits or ICs, totaled $15.5 billion in 1990, down 3.3% from $16.0 billion in 1989.

Integrated circuits (ICs) are semiconductor networks in a single package. Most ICs are monolithic, with all functions on a single chip. Monolithic ICs function as memories; as logic circuits; or as microprocessors, which are groups of logic circuits that form the heart of calculators or computers. Some ICs are hybrids, with several little chips combined on a single silicon substrate. ICs may be linear, which means they function in analog circuits, where the electrical signals vary in strength or amplitude (or sometimes, in frequency); or they may be digital, functioning in circuits where the signals are either "on" or "off"—1 or 0.

There are two basic technologies for manufacturing monolithic ICs—bipolar, and metal oxide silicon (MOS). Bipolars are more difficult to manufacture, but they are faster and, consequently, find their greatest applications in high-speed computers. They account for slightly less than half of all monolithic ICs, and are used mostly as logic circuits. In contrast, more than 40% of MOS ICs are used as memories, and another third are used as microprocessors or microcontrollers.

The semiconductor industry continues to earmark large sums for research and development. An important technological trend is the move toward greater chip density. There is a shift away from 4- and 8-bit microprocessors to 16- and 32-bit; and, in both random-access memories (RAMs) and read-only memories (ROMS), a shift away from 128-bit and smaller memories toward 256-bit, 1 megabit and even higher capacity memories. Another trend is toward the use of gallium arsenide (GaAs) in place of silicon as substrate material. While silicon is still used for the majority of all monolithic ICs, GaAs offers higher speeds, lower power dissipation, and higher resistance to radiation, which makes it of special interest to the military. However, while GaAs is very brittle, and tends

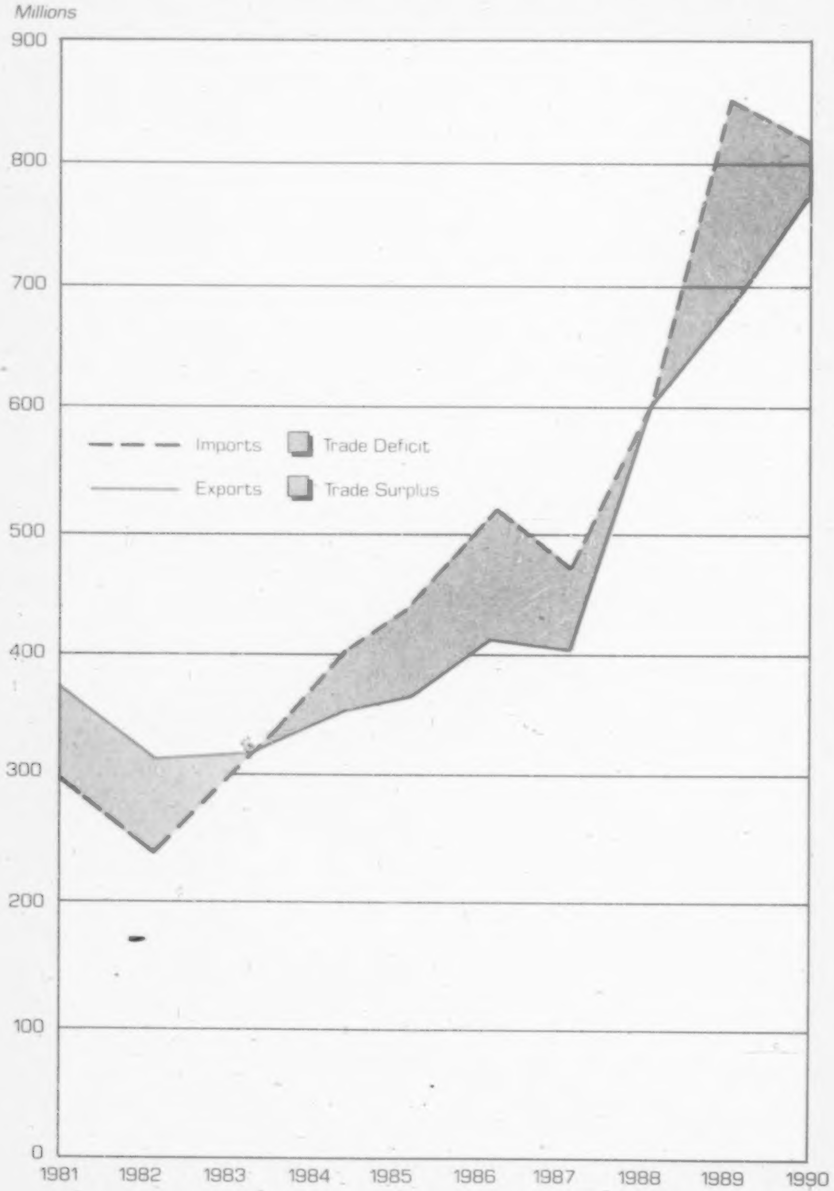
Imports of Monochrome Picture Tubes (Number of Units and Dollars); United States, 1986-1990 **TABLE 4-10**

	1986	1987	1988	1989	1990
Units	91,080	57,001	48,500	27,236	70,135
Dollars	$2,898,431	$2,100,479	$2,329,319	$1,816,128	$7,632,118

SOURCE: U.S. Department of Commerce.

to break during processing, it now appears practical to grow GaAs crystals on silicon substrates, which will result in combining the electrical advantages of GaAs with the better physical properties of silicon. A third technological trend is toward customizing or semi-customizing chips, particularly in application-specific integrated circuits (ASICs). The advantages of semi-custom devices over full-custom devices are lower nonrecurring costs—for engineering, tooling, etc.—shorter lead times, and lower prices. State of the art memory device technology will remain in the hands of Japanese manufacturers.

Imports[1] and Exports of Electron Tubes ($ Million); United States, 1981-1990 **FIGURE 4-8**



[1] Gross imports, 806.30 and 807 values included.

SOURCE: U.S. Department of Commerce.

Factory Shipments of Solid State Products ($ Million); United States, 1981-1990

TABLE 4-11

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
INTEGRATED MICROCIRCUITS (SEMI-CONDUCTOR NETWORKS)										
Hybrid integrated circuits, thick film composed of material deposited by silk screen process on a passive substrate combined with discrete active or passive components	378.0	434.7	468.4	639.2	557.7	547.8	800.3	863.1	839.9	800
Hybrid integrated circuits, thin film composed of material deposited by vacuum deposition, sputtering or similar process	245.3	215.8	261.6	315.9	527.5	520.8	489.8	517.8	463.8	420
Hybrid integrated circuits, multichip circuits not incorporating film techniques. These are usually combinations of chips, active and/or passive. Discrete package devices may be used for some, but not all of the circuits	173.6	204.0	81.7	95.4	82.8	79.2	91.8	149.0	167.3	165
Monolithic bipolar integrated circuits										
DTL (diode transistor logic)	14.0	8.5	na	na[1]	na[1]	na[1]	na[1]	na[1]	na[1]	na[1]
TTL (transistor transistor logic)	1,143.6	1,123.8	1,310.8	2,746.1	2,141.5	2,057.4	1,783.3	1,749.3	1,920.0	1,860
CML ECL (current mode logic emitter coupled logic)	199.2	190.3	113.4	247.9	287.8	215.3	404.3	280.1	271.1	255
Linear bipolar excl. microprocessors	na	na	na	885.2	1,070.0	1,227.5	1,454.3	1,730.0	2,006.0	2.000
Microprocessors			100.8	216.6	66.7	39.6	47.6	53.2	39.3	35
Other bipolar logic			1,221.5	437.1	463.9	243.0	402.1	544.9	405.2	350
Random access memories	na	na	na	85.8	77.2	63.1	152.3	97.6	47.4	40
Read only memories	na	na	na	20.1	71.9	75.3				
Other bipolar memories	na	na	na	211.3	162.5	174.6	114.5	171.9	135.1	115
Other bipolar integrated circuits	632.2	821.2	na	368.0	368.5	434.9	538.1	348.8	529.6	520
MOS (metal oxide semiconductors)	3,334.1	3,559.2	4,895.9	6,119.1	4,702.8	4,719.9	6,089.7	7,956.4	8,867.3	8.565
Other monolithic integrated circuits	856.4	764.2	406.6	572.4	225.1	417.2	482.4	402.5	307.6	340
TOTAL	6,976.4	7,321.7	8,860.7	12,960.1	10,806.0	10,815.6	12,850.5	14,864.6	15,999.6	15.465
TRANSISTORS										
Signal (less than 1 watt dissipation)	310.7	250.6	272.5	384.1	263.2	282.9	294.7	335.8	266.2	235
Power (1 watt or greater dissipation)	326.9	346.2	353.3	439.6	392.1	404.7	458.4	528.3	562.8	545
TOTAL	637.6	596.8	625.8	823.7	655.3	687.6	753.1	864.1	829.0	780
DIODES AND RECTIFIERS										
Signal diodes and assemblies thereof (maximum current 0.5 amps)	144.8	100.1	136.9	162.2	129.0	100.7	110.8	141.8	90.6	75
Semiconductor rectifiers. Power diodes and assemblies thereof (current rating greater than 0.5 amps)	253.2	212.3	208.7	217.7	323.6	287.2	344.7	362.9	358.6	330
Zener diodes (voltage regulator and voltage reference diodes)	118.4	97.6	100.4	179.1	140.6	148.9	141.1	166.1	161.0	140
Microwave diodes (mixers, detectors, varactors, parametric, harmonic generators, etc.)	96.2	80.5	92.3	99.3	110.2	111.5	133.1	131.4	126.7	110
Selenium rectifiers	2.9	3.0	2.8	3.3	2.8	2.8	3.9	4.7	4.2	4
Light emitting diodes (LED)	166.2	161.6	195.0	99.1	49.1	34.4	46.4	48.1	52.6	56
TOTAL	781.7	655.1	736.1	760.7	755.3	685.5	780.0	855.0	793.7	715
OTHER SEMICONDUCTOR DEVICES										
Light sensitive and light emitting devices:										
Solar cells	36.3	46.2	47.8	48.5	33.5	36.6	48.1	47.5	35.9	35
Photodiodes	[2]	[2]	[2]	10.4	11.3	14.9	26.8	39.0	50.0	55
Optical coupled isolators	[2]	[2]	[2]	65.9	69.6	73.7	47.9	77.0	79.5	85
Other light sensitive emitting devices	163.6	117.5	131.4	188.1	128.6	102.7	99.2	143.4	149.3	155
Thyristors (SCR's, triacs, PNPN diodes)	128.5	87.0	94.1	126.2	125.4	137.6	108.9	142.6	144.4	150
All other semiconductor devices	159.5	170.3	245.4	305.8	287.5	282.4	479.0	460.6	585.6	610
Semiconductor parts:										
Semiconductor devices and circuits: chips, (DICE) and wafers (DISCS)	994.8	1,390.4	1,313.5	1,162.4	1,152.7	944.1	1,189.7	1,617.5	2,230.1	2,350
All other semiconductor parts (headers, packages, heat sinks, other accessories, etc.)	436.5	343.7	515.4	579.9	625.5	627.7	436.1	678.7	1,478.5	1,550
TOTAL	1,913.2	2,155.1	2,347.6	2,487.2	2,434.1	2,219.7	2,435.7	3,206.3	4,753.3	4,990
GRAND TOTAL	10,308.9	10,728.7	12,570.2	17,031.7	14,650.7	14,408.4	16,819.3	19,790.0	22,375.6	21,950

[1] Included in "Other bipolar integrated circuits."
[2] Included in "Other light sensitive/emitting devices."
[r] Revised.
[e] Estimated.
na-Not available.
SOURCE: U.S. Department of Commerce.

Other Semiconductor Devices

Shipments of semiconductor devices other than ICs and transistors, diodes and rectifiers, totaled $4.99 billion in 1990, up 5% from $4.75 billion in 1989, continuing a steady growth trend which started in 1987. About 47% of the 1990 total was in shipments of chips and wafers for ICs and discrete semiconductors; another 31% was in shipments of other semiconductor parts, including headers, packages, and heat sinks.

Included in the remaining $1.09 billion of shipments were various light sensitive devices, such as solar cells and photodiodes, thyristors and all other semiconductor devices.

Imports and Exports of Solid-State Products

Exports of solid-state products increased 12.9% in 1990, to $13.5 billion, or 61% of total U.S. factory shipments of solid-state products (Table 4-12). Imports decreased 1%, to $12.2 billion. The $1.3 billion trade surplus was a strong improvement over the 1989 trade deficit.

According to U.S. Government data, imports of integrated circuits (ICs), the largest import category, totalled $9.7 billion in 1990, a decrease of 3.3% over 1989. IC exports reached $5.6 billion in 1990, as compared to 1989 exports of $5.1 billion. In 1990, there was a $4.1 billion trade deficit in ICs, an improvement over the $4.9 billion trade deficit in 1989. In 1990, trade in transistors reported $450 million in imports, a 10% increase over 1989, while exports were $219 million, a 5% increase over 1989. Imports of diodes and rectifiers totalled $566 million in 1990, a 7% increase over 1989.

Chips, dice and wafers remained the largest single export category at $6.5 billion, up 22% over 1989, and posted a positive trade balance of $5.5 billion. Semiconductor parts, excluding chips, dice and wafers, provided a positive trade balance of $340 million in 1990, down from $508 million in 1989.

Imports and Exports of Solid State Products ($ Million); United States, 1989-1990

TABLE 4-12

	1989	1990
Imports		
INTEGRATED CIRCUITS		
Monolithic, Linear	869.3	1,047.9
Monolithic, Bipolar	1,343.7	1,350.4
Monotholic, Metal Oxide Silicon (MOS)	6,918.2	6,347.8
Monolithic, Other	451.5	469.7
Other	486.6	521.4
TRANSISTORS		
Signal Transistors (Dissipation rates of less than one watt)	147.0	138.6
Power Transistors (Dissipation rates of one watt or more)	262.7	311.7
DIODES AND RECTIFIERS		
Solar Cells and Other Photosensitive	95.4	80.5
Zener	53.1	47.9
Microwave	15.9	24.3
Thyristors	74.5	82.6
LEDs	73.8	82.5
Other	218.3	248.5
OTHER		
Chips, Dice and Wafers	912.2	1,060.4
Parts of Semiconductors	381.5	369.3
Watch and Clock Modules	na	na
TOTAL	12,303.9	12,183.5
Exports		
INTEGRATED CIRCUITS		
Monolithic, Linear	462.5	553.3
Monolithic, Bipolar	752.9	661.5
Monolithc, Metal Oxide Silicon (MOS)	2,966.9	2,992.4
Monolithic, Other	522.4	937.2
Hybrid	427.1	479.9
TRANSISTORS		
Signal Transistors (Dissipation rating of less than one watt)	87.4	77.8
Power Transistors (Dissipation rating of one watt or more)	121.4	140.7
DIODES AND RECTIFIERS		
Solar Cells and Other Photosensitive	90.8	97.8
Zener	32.8	34.1
Microwave	32.0	32.3
Thyristors	30.7	26.1
LEDs	21.8	26.8
Other	79.1	89.3
OTHER		
Chips, Dice, and Wafers	5,385.0	6,547.9
Parts for Diodes, Rectifiers, Transistors, ICs and Semiconductors	889.1	709.3
Other Related Electronic Components	44.4	75.4
Watch and Clock Modules	na	na
TOTAL	11,946.2	13,481.8

na—not available

Totals may not add due to rounding

SOURCE: U.S. Department of Commerce

ELECTRONIC PARTS

Sales of electronic parts totaled $10.2 billion, down 3% from 1989 sales of $10.5 billion (Table 4-1).

Electronic parts are those components of electronic circuits that do not contribute to the electronic signal—as do tubes—and such solid-state devices as semiconductors; integrated circuits, etc. Parts include capacitors; resistors; passive networks; connectors; switches and relays; transformers and coils; quartz devices; filters; wire and cable; and TV and FM antennas and parts. For the most part, these components tune circuits, limit current flow, block the flow of direct current, and raise or lower voltages. To some degree, parts have been replaced by integrated circuits—a trend that will continue slowing growth in this market.

Capacitors

Factory sales of capacitors totaled 17.2 billion units, valued at $1,411.6 million during 1990 (Table 4-13). A breakdown of dollar sales by type shows that ceramic capacitors accounted for 44.3% of dollar sales; tantalum capacitors represented 23.8% of sales; paper and film types accounted for 17.5% of sales and aluminum capacitors claimed 10.6 % of total sales. All other types were placed at 3.8% of sales.

Of the 17.2 billion unit sales of capacitors during the year, 88.2% were ceramic types, with most of these (14 billion) multi-layer types. Tantalum sales accounted for 7.2%; paper and film types represented 3.1%; while aluminum capacitors were at 1.0%. Unit sales of all other types represented about 0.6% of total sales.

In electronic applications, capacitors are used for filtering, tuning, coupling, decoupling, isolation, and storage of electrical energy. Their biggest use is in consumer electronics equipment, including automotive, which, according to EIA, claimed about 39% of total unit sales and 21% of dollar sales. The distributor market accounted for 17% of the units shipped and 24% of total dollar value. Another major end-use market is the computer industry, which accounted for about 22% of unit sales and 17% of dollar sales in 1990.

The drive for surface mount devices is fueled by computers and automobiles: the latter are incorporating more and more electronics. The capacitor business should see significant growth in 1992 as the automotive, telecommunications and computer markets rebound.

In 1990, the trend toward surface-mounted capacitors (as opposed to leaded, or capacitors with wire leads) continued and was spurred on by the computer, telecommunications and automotive industries. Of the 15.2 billion ceramic capacitors sold, about 13.7 billion were multilayer (MLCs), and of these 65% were chips. Of the 1.2 billion tantalum capacitors sold, 33% were chips. Disk drive and automotive OEMs require increasing numbers of surface-mounted tantalum chips.

Adoption of just-in-time (JIT) delivery by original equipment manufacturers (OEMs) is another trend that is affecting the capacitor industry. It may be forcing capacitor manufacturers to increase their inventories, in order to deliver on a tight schedule.

Imports continue to be a serious challenge to U.S. manufacturers, particularly imports from Japan, but also those from South Korea, Taiwan, Singapore, and Hong Kong, and those from U.S. offshore plants throughout Southeast Asia. Imports from Mexico and the Pacific Rim countries partially result from assembly of U.S. products re-imported to the United States. Much of the exports went to the Common Market and to U.S.-owned offshore assembly facilities. Exports exceeded imports by $39 million, a five-fold increase in the capacitor trade surplus.

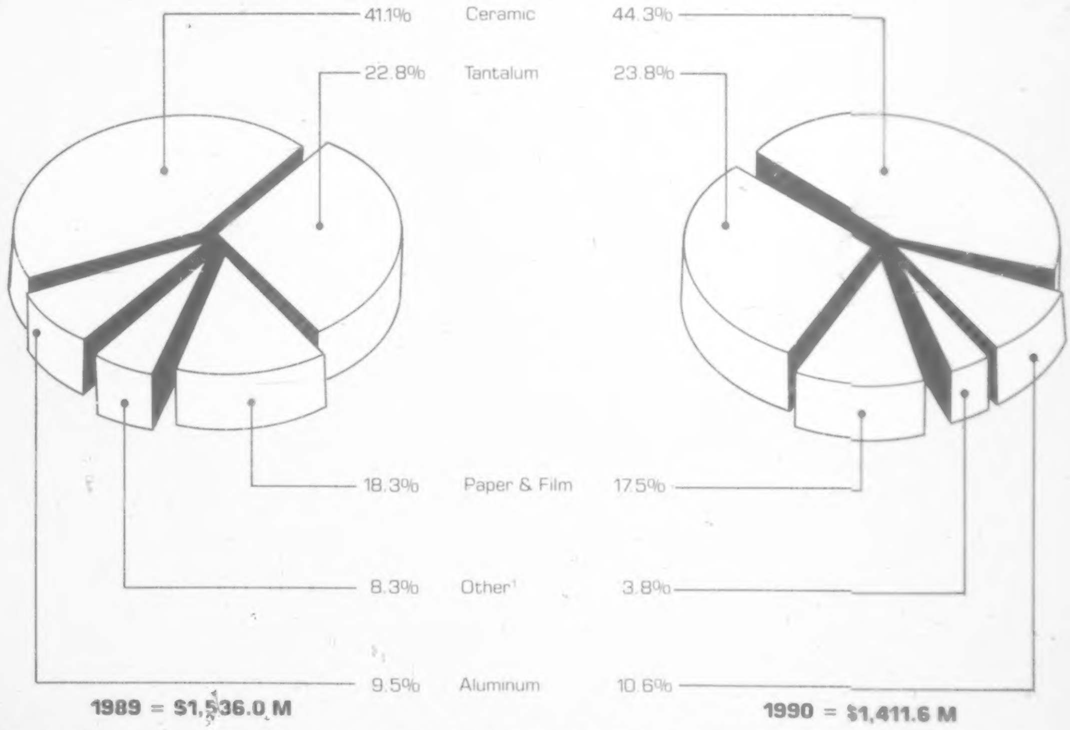
Resistors

During 1990, U.S. consumption of resistors, including chips, was 18.8 billion units, up 6% over 17.8 billion units in 1989. Dollar shipments reached an estimated $757 million in 1990, up 5.5% over comparable 1989 dollar sales of $717 million (Table 4-15). Resistor networks are treated separately (Table 4-16).

U.S. consumption of carbon-film resistors accounted for 32.2% of the discrete leaded resistor market in 1990, compared to 32.5% in 1989 (down from 36.3% in 1988). Metal and other film resistors accounted for 16.3% in 1990, compared to 17.0% in 1989 and 18.9% in 1988. Carbon composition resistors claimed a smaller share of the market—4.8% in 1990, as compared to 5.5% in 1989 and 6.1% in 1988. Fixed, wire-

Distribution of Factory Sales of Capacitors by Type (%); United States, 1989-1990

FIGURE 4-C



[1] Other indicates mica, ceramic microwave, all other ceramic types, C-networks, all other aluminum types, all other fixed types and variable.

SOURCE: Table 4-13

wound resistors continued to have a small, 2.1% share of the market, and variables of different types, including potentiometers and trimmers, claimed a 4.1% share of the discrete leaded resistor market.

The move toward surface-mounted resistors is gaining momentum but has been inhibited by relatively high prices and lack of standards. Standards have now been published, and eventually these will bring down the total cost-in-place of surface-mounted resistors. Increasing use of printed circuit boards by the automotive industry will also speed movement toward chip resistors. (The Japanese have converted to chip resistors to a greater extent than the U.S. industry, and this undoubtedly presages some acceleration in the trend toward surface mounts in the U.S.)

Imports accounted for 45% of 1990 resistor consumption, measured in dollars—a decrease from 48% in 1989. Imports

Factory Sales[1] of Capacitors (Millions of Units and Dollars); United States, 1989-1990

TABLE 4-13

CAPACITOR TYPES	1989		1990	
	UNITS	$	UNITS	$
Paper and Film Dielectric	597.3	281.5	518.1	246.4
Tantalum Electrolytic	1,103.6	349.9	1,243.1	335.7
Aluminum Electrolytic	173.3	146.6	155.6	149.6
Ceramic Dielectric, Fixed	15,258.9	630.8	15,208.0	625.9
Other[2]	207.5	127.2	110.1	54.0
TOTAL	17,340.6	1,536.0	17,234.9	1,411.6

[1] Includes factory sales and imports by U.S. manufacturers. Excludes sales by domestic manufacturers who do not sell at least 50% of their output to the commercial market.

[2] In 1989, other includes mica, ceramic microwave, all other ceramic types, C-networks, all other aluminum types, all other fixed types and variables. In 1990, other includes, mica, all other fixed types and variables.

SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Capacitors ($ Million); United States, 1975-1990

TABLE 4-14

YEAR	PAPER AND FILM	TANTALUM	ALUMINUM	MICA	CERAMIC	OTHER[4]	VARIABLE	TOTAL
1975	94	108	83	22	138	11	14	470
1976	129	131	111	24	185	12	16	608
1977	160	156	128	30	241	13	16	744
1978	205	188	151	[2]	289	43	20	896
1979	214	262	184	na	352	12	26	1,050
1980	208	470	178	na	407	14	22	1,299
1981	242	432	180	na	405	13	25	1,297
1982	233	348	158	na	398	12	20	1,169
1983	248	328	164	na	504	14	19	1,277
1984	314	413	189	na	670	16	17	1,619
1985	257	307	140	na	465	16	15[r]	1,200[r]
1986	263	302	131	na	493	15	19[r]	1,223[r]
1987	281	334	138	76[3]	546	14	22[r]	1,411[r]
1988	285	380	148	[2]	607	114[r]	[2]	1,534[r]
1989	281	350[r]	147[r]	[2]	631[r]	127	[2]	1,536[r]
1990	246	336	150	[2]	626	54	[2]	1,412

Totals may differ from Table 4-13 because of rounding.

[1] Includes capacitors imported for resale by domestic manufacturers. Sales by domestic manufacturers who do not sell at least 50% of their output to the commercial market are excluded.

[2] Combined with "Other."

[3] Mica includes other ceramic, other aluminum, and microwave chips.

[4] From 1987 to 1989, other includes ceramic microwave, other ceramic, C-networks, other aluminum, mica, all other fixed types and variable. In 1990, other includes mica, all other fixed types and variables.

na-Not available.

[r] Revised.

SOURCE: EIA Marketing Services Department.

Estimated Consumption of Resistors (Millions of Units and Dollars); United States, 1989-1990

TABLE 4-15

RESISTOR TYPES	1989 UNITS	1989 $	1990 UNITS	1990 $
Fixed:				
Carbon Composition	985.8	32.4	895.3	31.3
Carbon Film	5,782.5	27.4	6,074.0	29.3
Metal and Other Film	3,021.6	84.6	3,076.3	84.5
Wirewound	357.9	97.5	390.3	108.4
Chips	6,623.7	63.0	7,326.2	68.7
Variable:				
Wirewound	54.7	44.5	52.5	45.0
Non-Wirewound	676.9	312.0	713.5	329.0
Other[1]	296.4	55.5	309.3	60.3
TOTAL	17,799.5	716.9	18,837.4	756.5

[1] Includes varistors, thermistors, etc.

SOURCE: EIA Marketing Services Department

Sales of Passive Networks (Millions of Units and Dollars); United States, 1989-1990

TABLE 4-16

DESCRIPTION	1989 UNITS	1989 $	1990 UNITS	1990 $
Resistor Thin Film	23.1	21.0	23.2	20.4
Resistor Thick Film:	788.9	165.3	828.2	159.6
Resistor	765.6	150.2	814.0	149.5
Resistor-Capacitor	23.3	15.1	14.2	10.1
TOTAL PASSIVE NETWORKS	812.0	186.3	851.4	180.0

SOURCE: EIA Marketing Services Department.

Factory Sales of Accessory Parts of Televisions and FM Receivers (Thousands of Units and Dollars); United States, 1989-1990

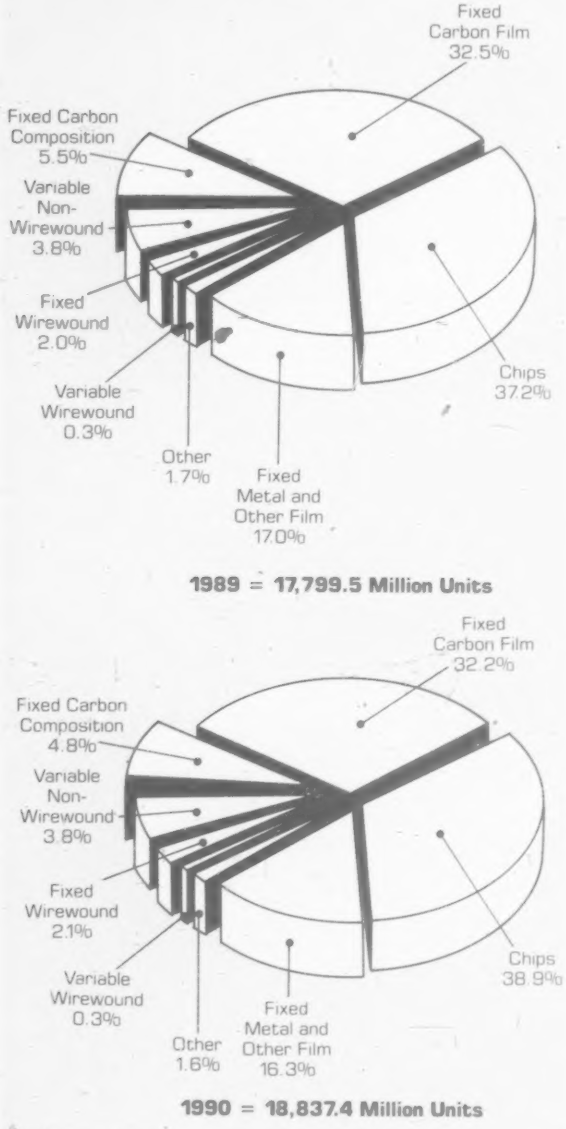
TABLE 4-17

PRODUCT	1989 UNITS	1989 $	1990 UNITS	1990 $	% CHANGE UNITS	% CHANGE $
Indoor Antennas	2,500	16,503	2,184	15,622	−12.6	− 5.3
Outdoor Antennas	1,067	28,564	964	26,542	− 9.7	− 7.1
Antenna Amplifiers	423	11,884	421	12,141	− 0.5	+ 2.2
Matching Transformers	3,303	2,014	3,227	1,933	− 2.3	− 4.0
Couplers and Splitters	3,588	3,787	3,937	4,065	+ 9.7	+ 7.3
Frequency Separators	345	612	425	998	+23.2	+63.1
TOTAL	11,226	63,364	11,158	61,301	− 0.6	− 3.3

SOURCE: EIA Marketing Services Department

Distribution of Consumption of Resistors by Type (%); United States, 1989-1990

FIGURE 4-D



decreased less than 1% in 1990, to $342 million. Exports of resistors declined 3.1% in 1990 to $255.7 million, resulting in an 8% increase in the deficit. Much of the imports, especially of carbon film and carbon composite resistors, comes from off-shore plants of U.S. manufacturers, mostly in Asia.

This is a mature industry, with a low margin of profit. There has been some capital investment in recent years to improve quality and reduce costs, but prospects are poor for much further investment or increased employment over the next five years—except in connection with resistor networks.

Networks

Sales of passive networks totaled 851.4 million units in 1990—valued at $180.0 million (Table 4-16). In units, this was a 5% increase over 1989, while dollar sales were down 4% from 1989.

Thick-film resistor networks made up 97% of the passive network units sold in 1990; about 3% were thin-film resistor networks. Of the thick-film resistor networks, about 2% included capacitors as well as resistors; the balance was resistors only. While unit sales increased in 1990, dollar sales declined.

With a softening in the computer market, as well as the military and telecommunications sectors, passive networks sales are expected to change little in 1991. Passive networks will continue to replace more individual resistors, while more and more of the resistive functions of electronic circuitry will be incorporated into integrated circuits.

Switches and Relays

Factory shipments of switches totalled an estimated $635 million in 1990, up 0.3% from 1989 shipments of $633 million (Table 4-18).

While switches are essentially very simple controls that translate manual motion to the opening and closing of electronic (and electrical) circuits, there are dozens of different types, with pushbutton, rotary, slide, and toggle types accounting for 50% of 1990 shipments. Shipments of the different switch types were essentially the same in 1990 as in 1989. Market shares, while varying considerably over time, were somewhat stable from 1989 to 1990, changing a few tenths of a percent. In the last two years, increases in market shares were posted by toggle and pushbutton types.

The only significant trend in the design of switches, which for the most part are electromechanical devices, are efforts to improve reliability. Growth of the market depends on increased sales of end-user products that incorporate switches—including personal computers and office automation equipment, telecommunications equipment, and to a lesser degree, industrial automation and military hardware.

According to EIA estimates, factory shipments of electronic relays totaled $460 million in 1990, a 3.8% decrease from 1989 sales of $478 million (Table 4-19).

Like switches, relays are devices for opening and closing electronic (and electrical) circuits, and are mainly electromechanical. However, while switches are activated manually, relays are activated by voltages created in testing, by closing of switches or other relays, by overloads, etc.

General-purpose electromechanical relays account for 29% of the total. Timing relays, miniature relays mounted on printed circuit boards and crystal can types account for 33%, while reed relays claimed 16% of total sales. Other types of relays, and parts, make up the balance.

In many respects, electromechanical relays would seem to represent an outdated technology that should be replaced by solid-state devices. However, there has been continued improvement in electromechanical relays—in miniaturization and reliability—and there has been a steady lowering of costs. According to Venture Development, U.S. consumption of electromechanical relays will grow at a 4.8% annual rate through 1994.

These trends have continuously delayed the long-expected shift to solid-state. Solid-state relays now account for only about 2% of the total, about the same share they have held

Factory Shipments of Switches ($ Million); United States, 1981-1990 **TABLE 4-18**

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
Toggle	77.1	89.0	104.3	98.2	77.1	86.7	93.9	97.6	100.5	103
Slide	64.7	58.5	69.1	67.6	62.8	66.4	75.9	83.1	80.1	78
Rotary	48.3	72.5	64.8	83.1	73.8	66.5	77.0	68.4	55.9	50
Keyboard	8.0	22.0	33.1	48.9	36.5	39.6	45.9	38.7	32.4	30
Pushbutton	40.2	38.5	47.1	96.2	72.2	48.0	92.6	50.9	52.5	55
Snap-Action	17.7	30.7	14.1	13.1	21.4	10.0	11.8	13.5	7.1	7
Thumbwheel						45.0	42.0	29.1	23.9	22
Other Switches	121.1	134.9	179.4	140.6	232.8	174.6	252.9	243.3	280.3	290
TOTAL	377.1	446.1	511.9	547.7	576.6	536.8	692.0	624.6	632.7	635

r-Revised
e-Estimated by EIA Marketing Services Department
na-Not available
SOURCE: U.S. Department of Commerce

for the last three years. One critical problem with solid-state relays has been power isolation. Solid-state relay pricing is fairly stable and it will be a while before prices start to decline. Top relay users (manufacturers of PBX, computers, disc drives and printers) are all demanding miniaturization, or high-density packaging, low power and high reliability.

Accessory Parts

Factory sales of accessories for TV and FM receivers in 1990 slipped 3.3% in dollar terms to $61.3 million, while unit sales also dropped to 11.2 million (Table 4-17). Indoor antennas saw unit sales drop 12.6%, while dollar sales were off 5.3%. Couplers and splitters recorded unit growth of 9.7% in 1990, reaching 3.9 million units, while dollar sales increased 7.3% to $4.1 billion.

Connectors

U.S. factory shipments of electronic connectors are estimated to have reached $3.3 billion in 1990, a decrease of 5.0% compared to 1989 (Table 4-20). Connectors represent 32% of the electronics parts market—twice that of any other part. *Electronics Purchasing* magazine cites several reasons why the

Factory Shipments of Electronic Relays ($ Million); United States, 1981-1990 **TABLE 4-19**

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
General purpose										
over 100 MW	56.3	42.8	49.7	241.9	244.5	210.0	187.4	146.5	121.4	109
0-100 MW						10.0	8.7	9.2	8.5	8
Solid State						21.8	11.9	15.6	15.9	16
Sensitive relays (through 100 MW)	11.9	10.7	na	na	na	na	na	na	na	na
Crystal can types	11.7	27.2	43.0	22.3	23.6	67.1	67.4	73.5	75.1	75
Reed relays	[1]	[1]	54.5[2]	69.6	130.5	86.3	86.2	78.4	77.0	75
Miniature printed circuit mounted (sealed and unsealed)	na	na	19.0	27.9	36.4	18.8	22.3	26.3	22.4	20
Timing relays	na	na	17.9	31.3	41.1	47.8	55.8	56.6	57.7	57
All other relays and parts	164.7	201.3	111.8	158.7	154.4	126.6	156.6	100.8	100.1	100
TOTAL	244.6	282.0	295.9	551.7	630.5	588.4	596.3	506.9	478.1	460

r-Revised
e-Estimated by EIA Marketing Services Department
na-Not available
[1] Included in "all other relays and parts."
[2] Includes dry reed only.
SOURCE: U.S. Department of Commerce

Factory Shipments of Electronic Connectors ($ Million); United States, 1981-1990 **TABLE 4-20**

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Coaxial	219.3	214.4	211.2	256.5	331.9	347.4	470.4	454.3	429.2	415
Cylindrical	455.3	387.6	414.7	466.0	452.7	463.4	573.5	578.7	506.1	465
Rack and Panel	393.1	385.2	420.1	483.8	360.9	437.4	499.8	513.6	467.6	440
Printed Circuit	460.1	444.4	598.0	724.0	728.8	728.1	998.3	1,149.8	959.6	875
Hermetic Sealed	50.8	90.0	152.5	177.1	168.8	152.1	174.5	126.9	125.2	125
Planar Cable[1]	232.0	208.8	263.2	310.0	217.8	212.6	229.5	247.3	240.3	235
Fiber Optic	na	na	na	*	*	5.8	8.1	6.8	15.2	20
Other	331.0	352.1	434.5	660.6	440.2	495.0	508.9	507.9	494.0	485
Parts for Connectors	61.0	65.7	91.8	122.4	199.7	183.9	166.2	162.5	211.5	215
TOTAL	2,202.6	2,148.2	2,586.0	3,200.4	2,900.8	3,025.7	3,629.2	3,747.8	3,448.7	3,275

[1] Includes fiber optic connectors in 1984 and 1985.
e-Estimated by EIA Marketing Services Department.
r-Revised.
na-Not available.
*Included in Planar Cable.
SOURCE: U.S. Department of Commerce.

ongoing rash of mergers and acquisitions will continue, including: pinched profit margins, overcapacity, over-abundance of suppliers, and marginal market growth. The shakedown is expected to continue through 1995.

Printed-circuit board connectors, mostly used with computers, continued as the leading type of connector, with 27% of the market in 1990, down slightly from 28% in 1989. Likewise, market shares for other types hardly changed—cylindrical connectors, used mainly in defense and transportation equipment, maintained about 14%; rack and panel connectors, also used in defense and transportation, were fairly steady at about 13%. Planar connectors and hermetic sealed connectors held their shares, 7% and 4%, respectively. Other types of connectors accounted for 15% of the total connector market, while parts for connectors accounted for 7%.

The high cost of fiber-optic connectors continues to limit this type to a small percentage of the market—less than 1%. While high cost has restrained growth for fiber optics in the commercial sector, the military has chosen the product for its superior technical advantages. With continued price erosion, the private sector is beginning to take advantage of fiber optics immunity to electromagnetic and radio frequency interference, its light weight, and its greater speed and bandwidth.

Exports accounted for 4% of 1990 shipments, down from 8% in 1989. Imports increased 23% in 1990, reaching $439.1 million. The resulting trade deficit in 1990 was $305.1 million, a nine-fold increase.

As circuitry speed increases and product size decreases, the industry will need to produce smaller connectors with more contacts in less space.

Transformers

U.S. factory shipments of transformers and coils reached $1.06 billion in 1990, according to EIA estimates (Table 4-23), a decline of 5.1% from 1989, continuing the downward trend from the 1988 high of 1.18 billion.

Factory Shipments of Quartz Devices ($ Million); United States, 1981-1990 **TABLE 4-21**

	1981	1982	1983	1984	1985	1986	1987	1988r	1989r	1990e
Oscillator Crystals	150.8	95.3	71.9	120.5	86.3	99.4	105.3	117.0	82.9	77
Crystal Oscillators	188.2	106.8	120.9	96.9	121.8	147.4	186.3	155.9	90.1	85
Crystal Filters	57.8	47.2	42.4	62.9	55.6	56.6	68.6	77.9	45.9	44
Crystal Blanks	15.9	16.9	21.7	59.9	74.5	15.9	34.6	30.2	28.6	29
TOTAL	412.7	266.2	256.9	340.2	338.2	319.3	394.8	381.0	248.5	235

e-Estimated by EIA Marketing Services Department.
r-Revised.
SOURCE: U.S. Department of Commerce.

Transformers are used to raise or lower AC voltages, or to insulate one AC circuit from another. Coils introduce inductance into AC circuits, which impedes the flow of AC current, and, with capacitors, can be used to tune such circuits

Audio transformers, which make up 9% of the market, decreased 6% in terms of dollar volume in 1990. Shipments of plate and filament transformers, representing 16% of the market, declined 5% in 1990. Pulse transformers, with 14% of the market, decreased 6%. Toroidal windings, with 9% of the market, were down 2.1%. RF chokes and coils, together accounting for 9% of the market, decreased 5% in 1990.

Chief end users of transformers are manufacturers of stereo and other home electronic equipment, computers, telecommunications equipment, industrial and control instrumentation, and the military. The larger of these manufacturers often wind their own transformers, and they account for about 30% of U.S. production. Most other transformers are produced by small independent companies.

Japan and Mexico have increased their penetration of this market, and accounted for the largest share of imports. With about 64% of U.S. production being exported, there was still a negative balance of trade of $1.6 billion in 1990, an increase from $1.3 billion in 1989. What technical development efforts there are with these products deal primarily with miniaturization, both of size and weight, in connection with surface mounting.

Factory Shipments of Filters ($ Million); United States, 1981-1990

TABLE 4-22

	1981	1982	1983	1984	1985	1986	1987	1988^{r}	1989^{r}	1990^{e}
Filters, except microwave:										
Mechanical	18.2	14.2	3.7	1.5	1.9	1.3	13.2	12.9	153.0	145
RFI/EMI Control	76.0	87.6	110.1	123.9	112.1	134.9	162.0	130.9		
Feed-thru and Bypass Capacitors	9.0	9.0	21.6	24.1	7.0	8.1	na	na	na	na
Electronic Wave	20.4	31.5	31.1	82.7	57.1	65.7	57.3	46.0	27.7	25
TOTAL	123.6	142.3	166.5	232.2	178.1	210.0	232.5	189.8	180.7	170

e-Estimated by EIA Marketing Services Department.
na-not available
r-Revised.
SOURCE: U.S. Department of Commerce.

Factory Shipments of Coils and Transformers ($Million); United States, 1981-1990

TABLE 4-23

	1981	1982	1983	1984	1985	1986	1987	1988^{r}	1989^{r}	1990^{e}
Audio Transformers	125.7	130.9	164.1	263.4	290.3	139.7	166.7	115.1	106.2	100
Low Frequency Chokes	26.6	26.2	27.0	30.0	29.9	34.3	33.9	55.0	49.8	45
Plate and Filament Transformers	202.2	187.1	196.0	192.5	186.1	174.1	188.4	191.4	174.4	165
Pulse Transformers, Computer and Other	96.4	98.5	88.2	113.5	124.4	143.1	160.4	174.5	153.7	145
RF Chokes	33.4	32.2	36.2	45.5	39.4	37.9	49.7	54.1	53.0	50
RF Coils	40.9	38.4	36.1	51.4	48.7	46.8	50.9	54.9	52.3	50
IF Transformers	16.3	19.9	15.6	19.0	20.9	16.2	14.2	14.7	14.6	14
TV Transformers & Reactors	71.7	35.1	46.8	35.0	38.9	38.2	35.6	32.4	28.4	26
Toroidal Windings	113.1	81.0	86.3	99.7	100.1	93.7	102.1	102.1	102.1	100
Other	226.0	192.7	269.2	205.1	300.3	317.7	347.0	389.0	381.9	365
TOTAL	952.3	842.0	965.5	1,055.1	1,179.0	1,041.7	1,148.9	1,183.2	1,116.4	1,060

e-Estimated by EIA Marketing Services Department.
r-Revised.
SOURCE: U.S. Department of Commerce.

Quartz Devices

U.S. factory shipments of quartz devices are estimated at $235 million in 1990, down 5.4% compared with 1989 shipments (Table 4-21).

Quartz devices take advantage of the fact that a quartz crystal will resonate at a fixed frequency, the exact frequency is dependent on its size and how it is cut (just as a diamond will reflect different wave lengths of light, depending on how it is cut). Quartz crystals are used in expensive clocks to establish frequency (in inexpensive watches, silicon dioxide crystals are used for this purpose); they are used to generate a reference frequency in various types of instruments; they control the operating frequency used by radio and TV transmitters, and by 2-way radio sets and cellular telephones; they are used as clocks in all personal computers; and they are used extensively by the military.

Oscillator crystals are the cut and polished crystals. Factory shipments declined 7.1% in 1990. Crystal oscillators are the crystals, plus associated circuitry. They accounted for 36% of quartz device shipments and recorded a sales loss of 5.7% in 1990. Crystal filters, which accounted for 19% of quartz device shipments, are filter circuits employing quartz crystals to block out unwanted frequencies. They experienced a 4% drop in sales in 1990. Crystal blanks—12% of quartz device sales—are the uncut crystals. They registered a 2% decline in sales in 1990.

Filters

U.S. factory shipments of filters totalled an estimated $170 million in 1990, representing a 6% drop from 1989 (Table 4-22).

Filters are used to prevent electronic equipment from radiating electrical waves that will interfere with other equipment—for example, they are used with computers to prevent computers from interfering with television sets; or they can be used with electronic equipment to suppress interference—surge protectors, for example. They are increasingly being used in communications and by the military.

Filters can be quartz devices, but most are based on properly designed capacitors. Radio-frequency interference (RFI) control filters and electro-magnetic interference (EMI) control filters are the most common types. RFI/EMI control filters accounted for 85% of all U.S.-manufactured filters (measured in dollars), and dropped 5.2% in 1990. Microwave filters, a relatively new type of filter which is increasingly being used with TV and communications equipment and in many military applications to keep out unwanted frequencies, accounted for about 15% of all filter sales, staying virtually flat in 1990. •

Printed-Circuit Boards

U.S. factory sales of printed-circuit boards are estimated to have totalled $6.4 billion in 1990, up 3% from the $6.2 billion reported by the U.S. Department of Commerce for 1989. U.S. imports of printed circuit boards reached $1.01 billion in 1989, up 56%. Exports totalled $1.9 billion in 1990, more than twice the level of export sales in 1989. Consequently, the 1990 trade surplus in printed circuit boards was $889 million.

Printed-circuit boards are the boards on which electronic components are mounted, and which have traces—the wiring pathways that interconnect the components—printed on the boards. They are used in all personal computers, and are widely used in all other computers, telecommunications equipment, instrumentation, and in the automotive market. Relatively small independent companies account for more than half of printed-circuit board production. About 10% of all production, as measured in dollars, is in single-sided boards. The balance is divided almost evenly between double-sided and multilayer boards, with multilayered boards growing at a slightly faster rate than double-sided boards.

Factory Shipments of Electronic Wire and Cable ($ Million); United States, 1981-1990

TABLE 4-24

	1981	1982	1983	1984	1985	1986	1987	1988[r]	1989[r]	1990[e]
Coaxial cable, armored or unarmored:										
Rigid and semiflexible	313.2	374.1	335.0	337.5	240.4	234.3	264.8	219.3	266.5	275
Flexible[1]	185.7	209.3	264.6	275.7	305.0	263.9	335.1	315.2	277.2	275
Antenna lead-in wire[2]	46.4	25.2	49.8	61.6	56.9	66.0	43.0	167.5	288.7	335
Hook-up wire, single conductor, shielded and nonshielded	239.0	222.6	245.7	291.7	274.4	275.3	354.4	332.4	327.0	325
Multiconductor, shielded and nonshielded:										
Flat and ribbon cable	38.7	54.8	80.3	93.4	73.9	78.2	86.0	102.4	82.3	85
Other	352.7	417.5	410.1	553.5	524.7	491.3	578.3	635.2	662.0	685
TOTAL	1,175.7	1,303.5	1,385.5	1,613.4	1,475.3	1,409.0	1,661.6	1,772.0	1,903.7	1,980

e-Estimated by EIA Marketing Services Department.
r-Revised.
[1] Includes CATV/broadcast coaxial in 1985.
[2] Includes CATV/broadcast coaxial subsequent to 1985.
SOURCE: U.S. Department of Commerce.

Balance of Trade for Electronic Parts ($ Million); United States, 1989-1990

TABLE 4-25

	IMPORTS		EXPORTS		BALANCE OF TRADE	
	1989	1990	1989	1990	1989	1990
Transformers, Rectifiers Rectifying Apparatus and Parts	2,105.4	2,300.0	821.8	676.8	−1,283.6	−1,623.2
Loudspeakers, Microphones and Amplifying Equipment	196.8	212.9	204.8	281.2	+8.0	+68.3
TV Tuners, Reception Equipment, and Parts of Phono and Tape Players	1,616.6	1,445.6	412.6	471.4	−1,204.0	−974.2
Capacitors	541.0	532.5	547.2	571.5	+6.2	+39.0
Circuit Breakers, Switches and Relays	1,017.1	1,147.7	448.4	788.3	−568.7	−359.4
Connectors	356.7	439.1	324.4	134.0	−32.3	−305.1
Printed Circuit Boards	1,011.4	1,002.0	868.4	1,891.0	−143.0	+889.0
Resistors	343.5	342.0	263.8	255.7	−79.7	−86.3
Wire and Cable	1,098.5	1,129.5	1,047.0	1,202.8	−51.5	+73.3
Other	245.3	250.9	123.6	134.5	−121.7	−116.4
TOTAL	8,532.3	8,802.2	5,062.0	6,407.2	−3,470.3	−2,395.0

SOURCE: U.S. Department of Commerce.

The predominant technological developments are trends toward miniaturization and toward finer lines, and as surface-mounted technology (SMT) becomes more widely used, toward the elimination of through-holes which are needed for components with leads, but not needed when components are soldered directly to copper traces.

Competition from Japan and Taiwan has caused printed-circuit board prices to drop, and in an effort to reduce costs, many U.S. manufacturers have moved production offshore.

Wire and Cable

Shipments of electronic wire and cable totaled a record high of $1.98 billion in 1990, up 4% over 1989 (Table 4-24). Antenna lead-in wire shipments increased 16%, and represented 17% of the market. Flexible coaxial cable, with 14% of the market, saw a slight decline in shipments, while rigid and semiflexible cable, also at 14% of the market, reported a minimal decline. Flat and ribbon multiconductor cable, with 4.3% of the market, recorded a 3.3% increase. Other multiconductor cable, with a 35% share, rose 3.5%.

Imports and Exports of Electronic Parts and Other Components

U.S. exports of electronic parts and other components increased 27% in 1990, reaching $6.4 billion. Printed circuit boards were the largest export category in 1990, increasing 118% to $1.9 billion. Wire and cable, the largest single export item in 1989, increased by a modest 15%, to $1.2 billion in 1990.

Total U.S. imports of electronic parts and components totaled $8.8 billion in 1990, up 3.5% from 1989. The largest decline was posted by TV tuners, reception equipment, and parts of phono and tape players, dropping 11% to $1.4 billion. The largest increase in imports was in the transformers, rectifiers, rectifying apparatus and parts sector, with an increase of 9% to $2.3 billion.

Despite the good performance in exports during 1990, the trade deficit for electronic parts and other components totaled $2.4 billion, reflecting an improvement of 31% over 1989's deficit of $3.5 billion. Four product types enjoyed a positive balance of trade in 1990—printed circuit boards, wire and cable, loudspeakers, and capacitors.

Government Electronics

The Fiscal Year 1992 Budget submitted by President Bush has a total outlay of $1.45 trillion (Table 5-1). Consistent with the five year deficit reduction law enacted in the Fall of 1990, the 1992 Budget recommends discretionary spending levels that fall within statutory caps for defense, international and domestic discretionary programs. A major unknown at this time is the spending that will be caused by the Persian Gulf war. Another area that is not predictable is the beginning of the resumption of the peacetime expansion, and how much of it will be related to the Gulf scenario. The budget request holds the rate of spending to approximately 2.6%, which is below the inflation rate. This budget enacts the concept of a flexible freeze to pull the budget into long term balance by FY 1996.

The President is proposing tax incentives to increase savings and long-term investment. He has proposed that domestic investment be increased in several areas. With education and human capital his goal is to better prepare children better for school, promote choice and excellence in our educational system, and improve math and science education. Another goal in the next generation is to reduce illness from preventable diseases, and to reverse the long term trend of underinvestment in children. In research and development and the human frontier, the budget recommends an increase of $8.4 billion in the federal investment in R&D, with special emphasis on basic research, high performance computing and energy R&D. In the transportation infrastructure, the government plans to expand investment in highways and bridges to over $20 billion within five years, and proposes substantial increases to improve conditions of the nation's airports. This would modernize the air traffic control system and continue to develop the transportation infrastructure for exploration into space. The goal of America's heritage and environmental protection includes implementation of the Clean Air Act and other key environmental statutes for the cleanup of pollution at various federal facilities, and at superfund sites.

There is an increase in the administration's investment in drug prevention treatment and law enforcement. The budget also contains funding for the President's commitment to better government management, including measures to improve accountability, to reduce waste, to reform regulation, to employ risk management budgeting in addressing threats to health and safety, and to set clear objectives and measure performance.

The budget reflects only a placeholder for Operation Desert Shield and Desert Storm. A supplemental request for these costs will be forwarded to the Congress later.

Figure 5-A depicts where the revenue originates and where it goes.

FISCAL YEAR 1992 BUDGET

With the action in the Persian Gulf drawing to a conclusion, we must take into account a scenario which envisions the buildup of Eastern Europe and a return to comparative stability in the Mid-East, as well as the U.S. budget deficit. This deficit is $318 billion in FY 1991, curving downward to a minuscule $2.9 billion in FY 1995 and then becoming a surplus of $19.9 billion in FY 1996. In FY 1992 the relationship of budget authority (BA) to outlays shows that the actual spending from 1992 is $1.066 trillion (Figure 5-B). Some spending will be added from unspent authority enacted in prior years.

The budget allocates about $76 billion for R&D, including R&D facilities, in 1992. This is an increase of over $8 billion.

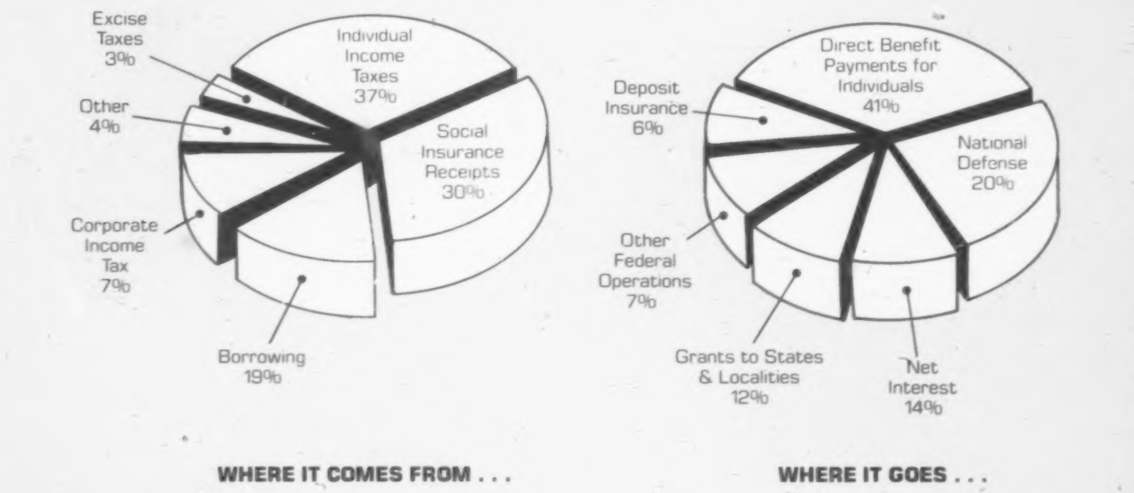
Receipts, Outlays, Deficit/Surplus Under the President's Proposed Policy ($ Billions) **TABLE 5-1**

	1990	1991	1992	1993	1994	1995	1996
Receipts	1,031.3	1,091.4	1,165.0	1,252.7	1,365.3	1,467.3	1,560.7
Outlays	1,251.7	1,409.6	1,445.9	1,454.2	1,427.1	1,470.3	1,540.8
Surplus or Deficit	−220.4	−318.1	−280.9	−201.5	−61.8	−2.9	+19.9

SOURCE: Budget of the United States Government, Fiscal Year 1992

The Federal Government Dollar Fiscal Year 1992 Estimate

FIGURE 5-A

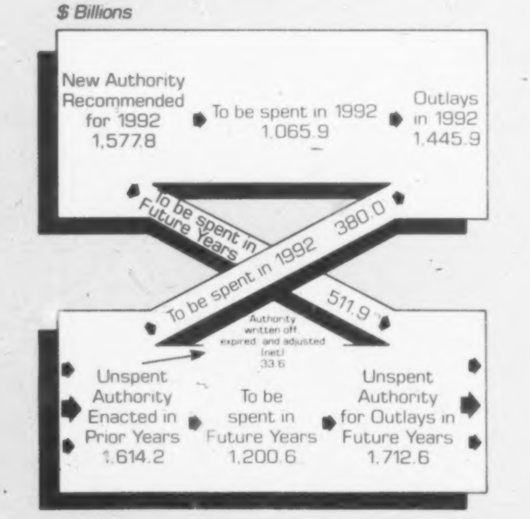


SOURCE: Budget of the United States Government, Fiscal Year 1992

or 13%, over 1991. There is $13 billion for basic research, an 8% increase over the previous year. The budget also provides over $16 billion for space activities. Falling under basic research is the superconducting super-collider (SSC), continuing on a 10 year design and construction schedule. Under applied research and development, there is an increase of $149 million, up 30% over 1991, to a total of $638 million for high performance computing and communications. Energy R&D budget proposes an increase of $227 million, or 34%, for investments in high payoff technologies and strategies. These are to increase the efficiency in energy use, to develop alternatives to petroleum and to advance new electricity technologies. Advanced manufacturing materials R&D includes over $1 billion for R&D on advanced manufacturing technologies, with opportunities in electronics and biomaterials. This also proposes $93 million for R&D on all aspects of superconductivity. In aeronautics R&D, the increased proposal is $61 million for NASA, up 13%, not including high performance computing.

Relationship of Budget Authority to Outlays—1992

FIGURE 5-B


$ Billions
New Authority Recommended for 1992 1,577.8
To be spent in 1992 1,065.9
Outlays in 1992 1,445.9
To be spent in Future Years
380.0
To be spent in 1992
511.9
Authority written off expired and adjusted (net) 33.6
Unspent Authority Enacted in Prior Years 1,614.2
To be spent in Future Years 1,200.6
Unspent Authority for Outlays in Future Years 1,712.6

SOURCE: Budget of the United States Government, Fiscal Year 1992

At the National Institute of Standards and Technology (NIST), the budget proposes a 15% increase to $248 million; the long term budget will double for NIST by 1996.

The highlights of space exploration include a proposed $5.5 billion for the space transportation infrastructure, including the space shuttle and expendable launch vehicles. Also proposed is a major new program jointly funded by NASA and the DoD to develop a new launch system, recommended by the Advisory Committee on the Future of the U.S. Space Program. In science, the budget proposes $2.1 billion, a 21% increase over 1991. This will support a broad range of space science activities including astronomy, unmanned planetary observation and planetary exploration, advanced space communications research and life sciences. For the U.S. global change research program (USGCRP), the budget proposes $1.2 billion, a 24% increase. This will be used to continue a broad range of research efforts including NASA's mission to planet earth/earth observing system (EOS), and high priority ground based programs such as the world ocean circulation experiment. Mission from planet earth proposes a 12% increase, to

$2.5 billion, for activities that will eventually lead to exploration of the moon and the planets, including Space Station Freedom. In biotechnology R&D, the proposal is nearly $4 billion. The federal outlays relation to GNP has been holding steady in recent years at 1.2%, while the R&D investment is about 3% of GNP.

Fiscal Year 1992 Defense Budget

The Administration sent the Department of Defense budget to Congress on February 4, 1991 (Table 5-2). Secretary Dick Cheney announced that the FY 1992 budget is $278.3 billion (Table 5-3) in budget authority (BA) and $283.0 billion in outlays. The services and agencies' individual requests are also shown (Table 5-4). Adjusting for inflation, this means a real decline in BA of 1% below FY 1991. Total BA for FY 1991 through FY 1995 will be $131 billion less than estimated in the President's January 1990 request. DoD outlays as a share of the U.S.'s Gross National Product (GNP) are expected to fall to 3.6% in FY 1996, the lowest level since before World War II, and well below the 4.7% reached during the defense decline of the 1970s (Figure 5-C). This biennial budget request comes down to the summit's lower defense levels through a combination of cuts in force structure and major procurement programs, management initiatives, and numerous reductions enacted during DoD scrutiny of the proposed budgets of the military services and defense agencies.

Costs associated with Operation Desert Shield and Operation Desert Storm will be handled on a supplemental budget request to be sent later.

The overall goal is to streamline and restructure America's armed forces, in order to provide needed capabilities within projected fiscal constraints. In essence, U.S. forces are becoming smaller, but still fully capable of securing our nation and its global interests. Rapid response to global crises requires sustainment of the current high quality and superior capabilities of U.S. forces, especially as their total size is reduced. This in turn drives requirements for high quality of U.S. military personnel, vigorous defense research and development, the fielding of advanced military systems as soon as they are needed, and the preservation of critical elements of America's defense industrial and technology base. These priorities also enable DoD to reconstitute a larger military posture, if needed.

Other priorities include the ability to rapidly project military power to areas of U.S. strategic interest. The new approach also requires that U.S. forces sustain their traditional high readiness. To ensure credible nuclear deterrence, the DoD will maintain strong offensive nuclear forces, and pursue strategic and theater defenses to provide global protection against limited ballistic missile strikes (Table 5-5). The budget also reflects Secretary Cheney's commitment to continued strengthening of defense management and streamlining of the U.S. defense infrastructure, to extract the greatest security value from increasingly scarce resources. The DoD is paying special attention to efficient acquisition. Goals also include funding sustainable production rates for essential programs and terminating lower priority programs.

Military Personnel

In connection with the restructuring of the armed forces, military manpower will decline considerably. By the end of FY 1995, active military end strength will fall to 1.6 million, 24% below its post-Vietnam peak of 2.17 million in FY 1987. In 1995, reserve levels will drop to .91 million, 21% below the 1987 peak. The DoD continues to support the pay and other incentives aimed at preserving the high quality and morale of America's uniformed men and women. The budget requests pay raises of 4.2% for FY 1992 and 4.7% for FY 1993. These proposals are based on projected increases in the Employment Cost Index.

Strategic Forces

Funding for the Rail-garrison Peacekeeper is cut back significantly, but development of the small ICBM is continuing. No Trident submarines will be built beyond the 18th boat approved in the FY 1991 budget. ASAT funding has been substantially reduced. The backfit of eight Trident submarines to carry D-5 missiles has been deferred beyond FY 1997. The Milstar satellite program has been substantially restructured to reduce costs, eliminate certain expensive survivability features, and most effectively support both tactical and strategic requirements. The B-2 Stealth bomber program calls for procurement of four aircraft in FY 1992 and seven in FY 1993.

General Purposes Forces

The Army's major modernization effort, begun in the early 1980s, is nearly complete. However, important development continues on the Light Helicopter and armored vehicles.

Procurement of the Navy's SSN-21 attack submarine has been scaled back to one per year. Other naval modernization

National Defense Topline (Current $ Billions) TABLE 5-2

	1991	1992	1993	1994	1995	1996
BUDGET AUTHORITY						
DoD 051	273.0	278.3	277.9	278.2	280.7	282.6
DoE & Other	12.6	12.5	13.0	13.7	14.4	15.1
TOTAL 050	285.6	290.8	290.9	291.9	295.1	297.8
OUTLAYS						
DoD 051	287.5	283.0	279.1	273.3	274.6	278.5
DoE & Other	11.5	12.2	12.8	13.4	14.0	14.7
TOTAL 050	298.9	295.2	292.0	286.7	288.6	293.2

SOURCE: Secretary of Defense News Release, February 4, 1991

Department of Defense—Budget Authority by Title (Current $ Billions)

TABLE 5-3

	FY 1990	FY 1991	FY 1992	FY 1993
Military Personnel	78.9	79.0	78.0	77.5
O&M	88.3	86.0	86.5	84.7
Procurement	81.4	64.1	63.4	66.7
RDT&E	36.5	34.6	39.9	41.0
Military Construction	5.1	5.0	4.5	3.7
Family Housing	3.1	3.3	3.6	3.6
Other	−0.3	1.0	2.3	0.7
TOTAL	293.0	273.0	278.3	277.9

SOURCE: Secretary of Defense News Release, February 4, 1991

priorities include Aegis destroyers, F/A-18 fighters, and several types of tactical missiles. Regarding sealift, the DoD expects to be able to meet its most important contingency requirements worldwide, especially because of the programmed increase of the Ready Reserve Force (RRF) from 96 to 142 cargo and tanker ships by FY 1994. The DoD is also initiating a sealift program in FY 1993 to improve U.S. response time for those contingencies.

Modernization of U.S. tactical air forces continues with procurement of F-16 fighters, D-130 transports, and AMRAAM missiles. The next generation air superiority fighter—the Advanced Tactical Fighter (ATF)—continues to be developed.

The C-17 program has been scaled back and extended. U.S. airlift capacity will remain at current levels through FY 1995, then modestly increase, as the fielding of C-17s exceeds the retirement of C-141s.

Research and Technology

Reflecting the emphasis on preserving the technological superiority of U.S. forces, FY 1993 RDT&E budget authority will, after inflation, be 10% above FY 1991 levels. DoD Technology Base funding—$3.9 billion in FY 1992 and $4.0 billion in FY 1993—will include emphasis on high performance computing and improved materials for electronics, gas turbine engines, and airframe components. To increase efficiency and reduce the costs of RDT&E operations, there will be greater cooperation within the Department on specific technology areas, consolidation of facilities, and enhanced competition for Science and Technology (S&T) tasks among laboratories. Management oversight will also be increased to improve the quality, productivity, and effectiveness of RDT&E operations.

Defense Management

The DoD management continues to undergo fundamental change through implementation of Secretary Cheney's July 1989 Defense Management Report (DMR). Special emphasis is on streamlining and improving defense acquisition. The DoD is eliminating unnecessary management layers, limiting unneeded reporting requirements, reducing burdensome regulations, and enhancing the education and quality of its acquisition professionals. Central to these management efforts is the goal of bringing down the Department's cost of doing business, through reducing overhead, cutting excess infrastructure and redundancy, and consolidating and improving a number of common functions. An example is the creation of the Defense Finance and Accounting Service (DFAS).

Other management improvements involve supply operations, maintenance depots, and RDT&E, mentioned above. To enhance supply depot efficiency, DoD will consolidate the management of supply operations under the Defense Logistics Agency. A Defense Depot Maintenance Council has been established to provide recommendations on increasing the efficiency of maintenance depots. These efforts include the under secretaries of each military department establishing management efficiencies through enhanced competition and cooperation, as well as better utilization of the depots.

Department of Defense—Budget Authority by Component (Current $ Billions)

TABLE 5-4

	FY 1990	FY 1991	FY 1992	FY 1993
Army	78.5	72.4	71.1	67.7
Navy	100.0	92.2	91.6	92.5
Air Force	92.9	82.7	86.5	91.4
Defense Agencies/Defense Wide	21.7	25.7	29.1	26.3
TOTAL	293.0	273.0	278.3	277.9

SOURCE: Secretary of Defense News Release, February 4, 1991

FY 1992/FY 1993 Strategic Forces ($ Millions) **TABLE 5-5**

System	FY 1992 Quantity	FY 1992 Dollars	FY 1993 Quantity	FY 1993 Dollars
B-2A Bomber	4	4,822	7	4,639
Strategic Defense Initiative	–	4,581	–	4,933
TRIDENT II Missile	28	1,271	31	1,380
PEACEKEEPER/Rail Garrison	–	458	–	106
Small ICBM	–	549	–	715
Advanced Cruise Missile	120	626	102	552

SOURCE: Secretary of Defense News Release, February 4, 1991

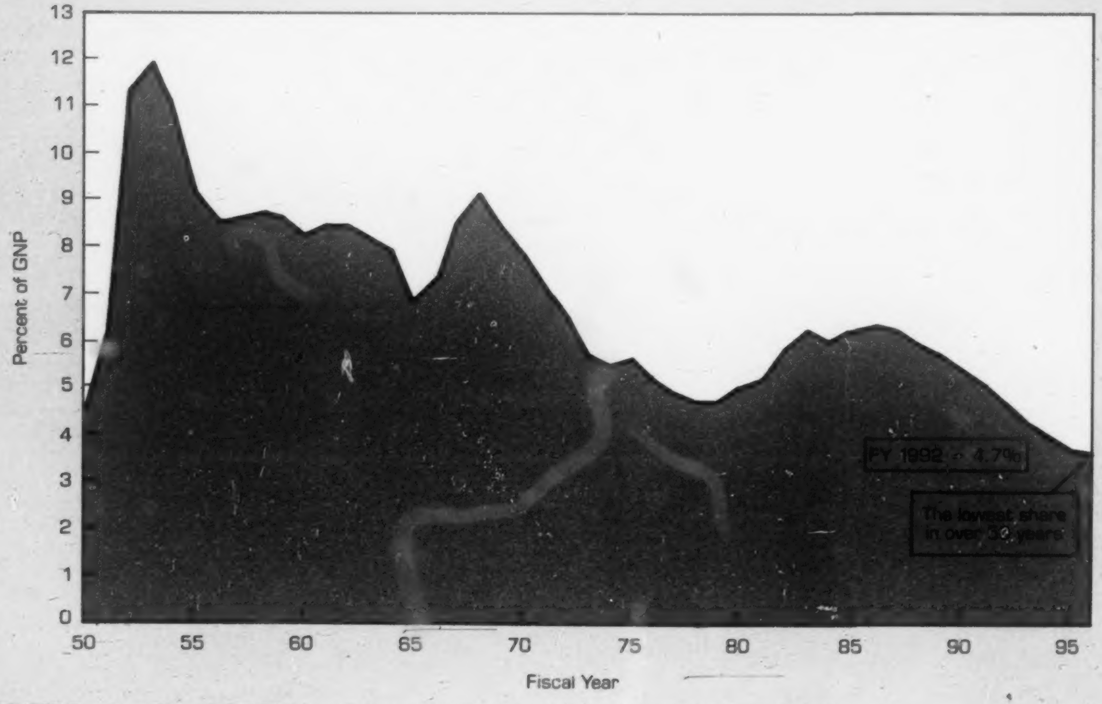
As a result of its DMR-related management efforts, the DoD anticipates reductions of over 30,000 civilian and 40,000 military positions by the end of FY 1997. The DoD expects its management initiatives to save about $72 billion from FY 1991 through FY 1997.

The Strategic Defense Initiative (SDI)

The new SDI program focus is on global protection against limited strikes (GPALS). The revolutionary changes taking place in the international political and security environment have served to underscore the fact that the strategic environment the U.S. will confront in the 1990s will differ significantly from that faced in the mid-1980s when the SDI was established. In light of success in negotiating an Intermediate Range Nuclear Forces (INF) treaty, which has sharply reduced the nuclear threat in Europe, the Conventional Forces in Europe (CFE) treaty, which when fully implemented, will put an end to the imbalance of conventional forces in Europe; and the efforts to finalize a START treaty, the U.S. may no longer face the threat of an unlimited competition with the Soviet Union in the area of strategic forces.

At the same time, the threat posed by accidental or unauthorized launch of ballistic missiles is of growing concern, and

Defense Outlays as a Share of GNP **FIGURE 5-C**



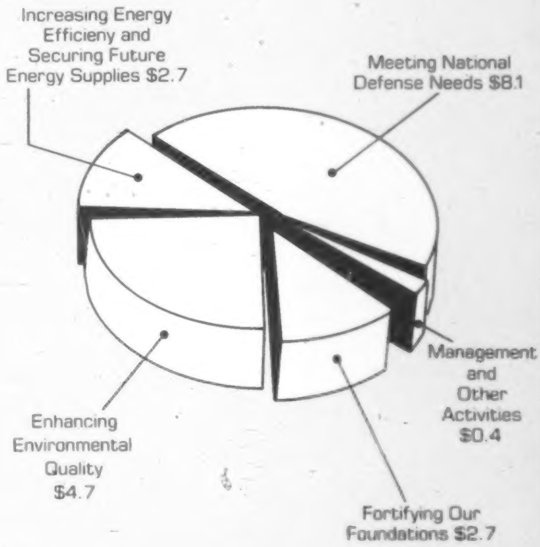
SOURCE: Secretary Cheney FY 92-93 Budget Testimony To House Armed Services Committee, February 4, 1991 compounded by widespread ballistic missile proliferation. As a result, the U.S. and its friends and allies face a growing threat from limited ballistic missile strikes. Therefore, the President has directed the refocus of the SDI program to provide GPALS. The total budget for SDI in FY 1992 is $4.58 billion; for FY 1993 it is $4.93 billion (Table 5-6).

The Department of Energy Budget

The proposed U.S. Department of Energy budget for FY 1992 is $18.6 billion, up about 1% over the FY 1991 funding level (Figure 5-D). DOE remains committed to the technologies which contribute to securing future energy supplies, and has increased requests for funding in several areas. The budget request for increasing energy efficiency is 25% higher than the FY 1991 level, reflecting the emphasis on energy efficiency improvements in the National Energy Strategy. Enhancing environmental quality is an across the board emphasis, including Environmental Restoration and Waste Management oversight programs. The budget request for fortifying our foundations is up 16% to $2.7 billion (not including increases in both Science and Mathematics Education and Technology Transfer). This includes increases in almost all programs, with a major increase in funding for the Superconducting Super Collider and a substantial gain in High Energy Physics. Meeting national defense needs decreases slightly, as the budgets for weapons and materials production decline from the FY 1991 levels (Table 5-7).

DOE Budget Request
($ Billions)

FIGURE 5-D



FY 1991 Budget Authority—$18.6 billion

SOURCE: Department of Energy

The NASA Budget

The National Aeronautics and Space Administration (NASA) FY 1992 budget requests $15.7 billion, a 13.6% increase over FY 1991 (Figure 5-E). It provides for two significant new initiatives: a New Launch System jointly developed with the DoD to provide a range of cargo capacities including heavy lift, and LIFESAT, and a multi-launch recoverable biosatellite to help determine radiation protection requirements for long-duration space flight. The budget also proposes to initiate a new program, Assured Shuttle Availability, that will improve the nation's ability to identify and incorporate high-priority improvements into the Shuttle.

Space Science will continue as a top priority with a 21% increase over last year. Space Station Freedom is the cornerstone of America's space exploration program. It will be able to meet its priority user requirements: life sciences and microgravity research. Specifically, during 1991-1992, NASA is scheduled to launch the Gamma Ray Observatory, the Extreme Ultraviolet Explorer, the Upper Atmosheric Research Satellite, the Advanced Communication Technology Satellite, the Mars Observer, the TOPEX, and several Spacelab missions. The mission to planet earth remains a high priority, as does the mission *from* planet earth. The mission *from* planet earth has the long-range program for human exploration of

Strategic Defense Initiative FY 92-93 President's Budget
($ Millions)

TABLE 5-6

	FY 91 Appropriated	FY 92 Budget	FY 93 Budget
RDT&E			
Phase I Defenses	870.482	1,612.267	1,593.406
Limited Protection Systems	395.843	674.440	747.530
Theater And ATBM Defenses	184.000	279.460	340.680
Follow-on Systems	706.640	925.149	1,016.342
Research And Support Activities	733.035	1,081.258	1,235.261
Total RDT&E	2,890.000	4,572.574	4,933.219
MILCON	11.370	8.100	0.000
Total	2,901.370	4,580.674	4,933.219

SOURCE: SDI FY 92-93 Budget Brief

Department of Energy—Budget Authority for Atomic Energy Defense Activities ($ Thousands) **TABLE 5-7**

	FY 1991 Comp	FY 1992 Request
Weapons Activities:		
Research, Development and Testing	1,737,075	$1,764,000
Production and Surveillance	2,792,354	2,548,500
Program Direction—Defense Programs	91,670	164,000
Subtotal, Weapons Activities	4,621,099	4,476,500
Materials Production	1,951,333	1,876,900
New Production Reactors	375,000	500,000
Verification and Control Technology	154,529	185,000
Nuclear Safeguards and Security	91,000	96,000
Security Investigation	65,000	62,600
Intelligence	41,879	50,000
Security Evaluation	14,755	15,000
Naval Reactors	769,801	801,000
Environmental Restoration & Waste Mgmt:		
Corrective Activities—Environment	78,947	32,588
Corrective Activities—Defense Program	84,090	59,947
Environmental Restoration (AED)	978,641	1,074,392
Waste Management (AED)	2,009,243	2,185,076
Technology Development (AED)	235,967	309,378
Transportation Management	15,191	18,870
Program Direction	53,658	24,749
Total, Environmental Restoration & Waste Mgmt	3,455,737	3,705,000
Subtotal, Atomic Energy Defense Activities	11,540,133	11,768,000
FY 1991 Supplemental	−623,000	—
Prior Year Balances and Other Adjustments	50,000	—
Total, Atomic Energy Defense Activities	$10,967,133	$11,768,000

SOURCE: Department of Energy

the Moon and the planets. The focus in FY 1992 will be on continued mission studies and long-lead exploration techniques such as life support and nuclear propulsion.

The Department of Transportation Budget

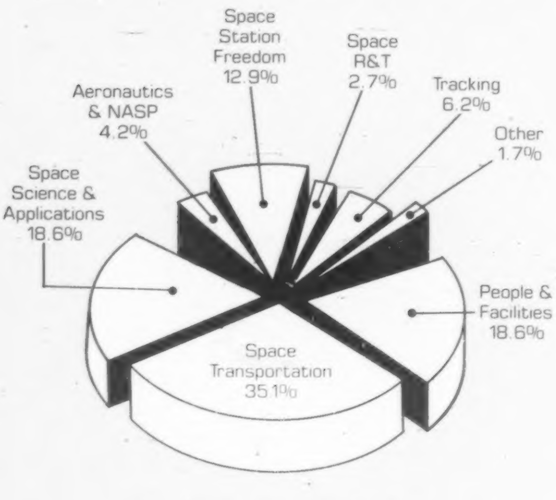
In support of the National Transportation Policy (NTP), the Department of Transportation's (DOT) FY 1992 budget request totals $33.55 billion in appropriations and obligation limitations (Figure 5-F). This is 24.8% above the FY 1991 budget, and 6.3% above the enacted level. The growth reflected in this budget supports critical initiatives important to the DOT and to the goals of: support for the President's aviation programs reflected in the recently enacted legislation; investment in surface transportation infrastructure as the centerpiece of the proposal for reauthorization of surface transportation programs; maintenance of a strong and effective Coast Guard; continuing support for safety programs; investment in research and development across the DOT; and support to assure a quality DOT workforce.

Nearly $24 billion, or 71% of the budget, is for programs directly supporting capital investments in highway, transit, rail, and aviation infrastructure. This includes $19.3 billion for surface transportation investments—a 6% increase over 1991. In order to foster a sound financial base for transportation, the budget continues to rely heavily on user fees rather than general funds to finance transportation programs. The DOT wants to ensure that the transportation system supports public safety and national security. The budget includes $1.8 billion for direct, operational safety programs, a 14% increase over FY 1991, needed to carry out the Department's responsibilities to ensure a safe transportation system. This amount includes funds for inspections, search and rescue, safety grants to States and transportation security. The budget also continues efforts to ensure that transportation services are drug-free, and supports the nation's overall drug interdiction strategy. It proposes $751 million, essentially the same as FY 1991, to maintain these efforts.

For FY 1992 the Federal Aviation Administration (FAA) funding is up 14% to $9.3 billion. Highlights include an addition of 450 air traffic controllers for a total of 17,945, 100 new aviation inspectors, and 178 new civilian aviation security personnel. Under the facilities and equipment portion of the budget, major new systems proposed include: the Advanced Automation System, Voice Switching and Control System, Long Range Radars, Automated Weather Observing Systems, and facilities in support of major hub airport capacity expansion. The research, engineering and development increase of 2% will continue to modernize communications systems, and systems for the acquisition, processing, dissemination, and display of weather information tailored to the needs of aviation users.

The United States Coast Guard budget requests a funding of $3.63 billion, an 8% increase over the enacted 1991 level.

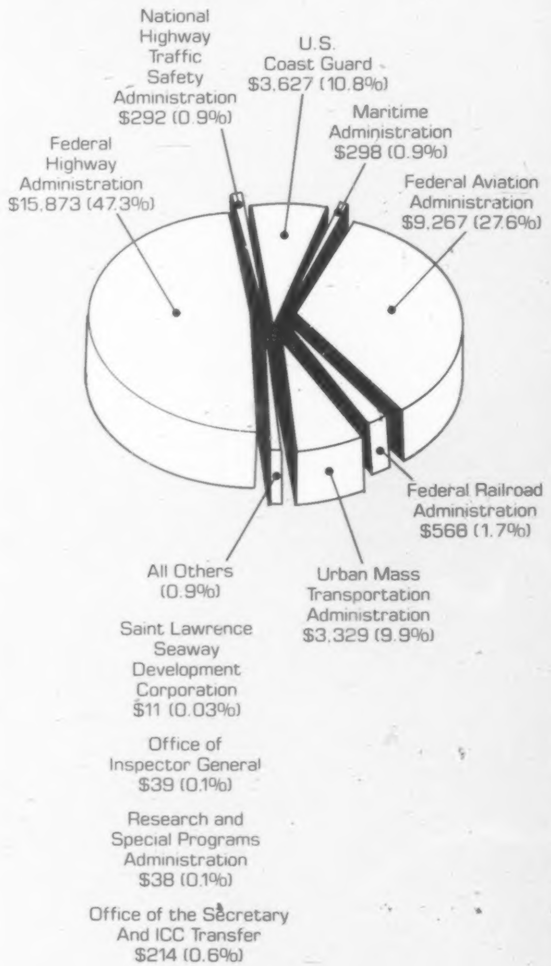
NASA Budget Request, FY 1992 **FIGURE 5-E**



FY 1992 = $15,754 Million

SOURCE: NASA Administrator Richard H. Truly, NASA Budget Press Conference, February 4, 1991

Department of Transportation: FY 1992 Appropriations and Obligation Limitations in Appropriation Acts ($ Millions) **FIGURE 5-F**



DOT Total—$33,554

SOURCE: Department of Transportation

The emphasis on marine environmental and law enforcement efforts continues, while maintaining the Coast Guard's traditional strong roles of protecting and saving lives at sea, and serving in the nation's defense. Some of the highlights of the USCG budget include $2.54 billion for operating expenses to operate and maintain a wide range of multimission vessels, aircraft, shore units and aids to navigation. $423 million is requested to fund capital improvements, including vessel and aircraft acquisition, replacement, and rehabilitation; information management resources; and construction and renovation programs at selected shore facilities. The RDT&E request for $28.8 million is a 15% increase over FY 1991, to fund the development of hardware, procedures, and systems that directly contribute to increasing the productivity of Coast Guard operating and regulatory programs.

THE MILITARY ELECTRONICS MARKET: A TEN YEAR FORECAST

For the 26th consecutive year, the Electronic Industries Association (EIA) Government Division Requirements Committee members presented the EIA Ten-Year Forecast of Defense electronics needs. The initial process for the presentation was the evaluation of the R-1, P-1 DoD budget data and the budget request proposed by the President. The Forecast subcommittee reviewed the significant literature, and conducted a series of interviews with key government officials knowledgeable in the areas of defense, budgets and fiscal policy; defense analysts from private institutions; and aerospace experts from investment firms. After analyzing the obtained information, the Forecast subcommittee was then able to determine force structure implications for the decade to come. Some of those interviewed believe that the decline in budget will continue or accelerate at the latter part of the decade, while others argue that decline will be slow. Our forecast shows a one-third decline in real terms from about $300 billion in FY90 to just over $200 billion in FY2000.

Factors Shaping Future Defense Budget: Force Structure

Force structure implications over the next ten years will feel a 5% change by way of reduction in military personnel. This reduction will be more evident in the shift away from the active force toward the reserves and National Guard. The existing unified commands will, over the next decade, show drastic declines in active divisions within the force structure. The possible command structure changes include a land-based Atlantic force with Army responsibility; a Pacific-based maritime force with a Navy orientation; a contingency force (SOCOM) designed to rapidly respond to Third World situations; and an Air Force oriented strategic force including military space.

The Army, with a 42% cut in active forces, will be U.S.-based with limited investment programs. The Navy, with a 32 percent cut in active forces, will focus primarily on anti-ship missile concerns, with ship building programs being reduced and new aircraft programs being started. The Marines, losing only 25 percent, will stay at the statute-mandated three divisions but will experience a mission overlap between forces. The Air Force, with a 41 percent cut in active forces, will face a TAC AIR reduction, limited forward basing, new aircraft programs being stretched out and identified mission overlaps between forces. The Special Operation Forces (SOF) are expected to show an increase in percentage of total budget, reversing the decline of the past several years.

With the reduced force structure, risks are very evident. Military strength may become inconsistent with reduced force structure; 'defensive trip wires' and 'defensive defense' will continue to prove to be a weak deterrent concept and the economies of scale and benefits of unique infrastructure will be diminished.

Individual Appropriations Category Forecast

Military Personnel

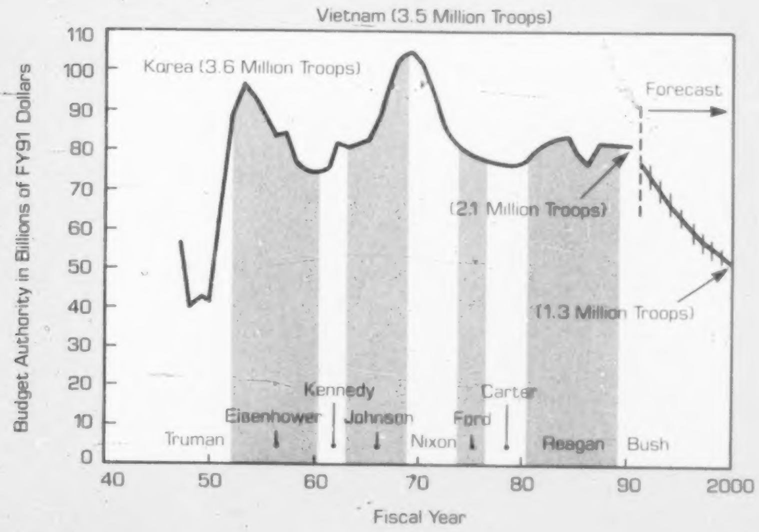
Figure 5-G plots the beginning of the Cold War period through the EIA 10 year forecast period. During the Korean War there were 3.6 million troops; during the Vietnam War there were 3.5 million troops; and now there are 2.1 million. Previously the military personnel account had funded both the active troops and the components for the Reserve and National Guard; this year they continue to be cut. The end-strength reductions will drive the military personnel account to the lowest level in almost 50 years and will place us back, in real terms, to the budget numbers seen before the Korean War.

The EIA forecasts an active force reduction of 770,000 troops by FY 2000. This will leave us with an active force of 1.3 million in FY 2000. Active land force divisions will drop from 21 to 13; active attack wings for all services will be cut from 40 to 25; and cruiser battle groups will drop from 14 to 10.

Operations & Maintenance

Regardless of what has been occurring with end-strength, O&M accounts over the years have been increasing. The increases are going back to the same budget dollar levels of the late 1970s. Reasons cited have been linked to the use of surrogates, simulators, and other training devices to compensate for the sophisticated and older systems which require higher O&M cost. The buys for replenishments and spares are going to be shifted from the procurement account to the O&M account in the FY92/FY93 period. Civilians have been cut back; savings from Defense Management Review (DMR) board implementations and base closing will all help to reduce

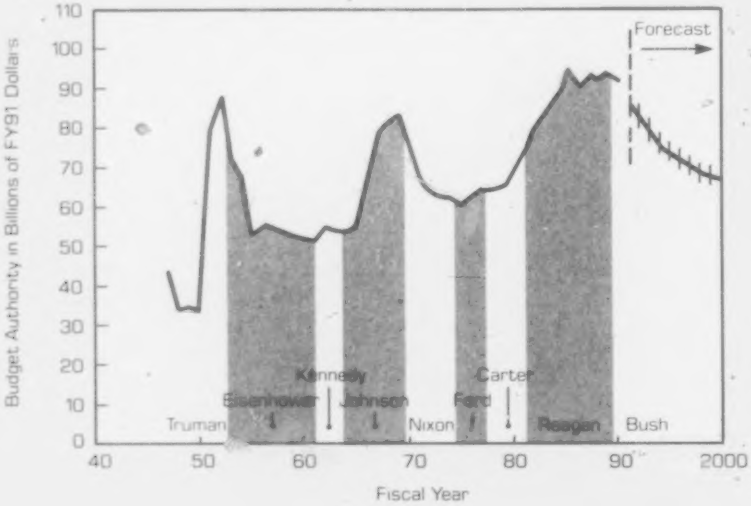
End-Strength Reductions Drive Mil Pers Account to Lowest Level in 50 Years **FIGURE 5-G**



SOURCE: Electronic Industries Association

O&M Level is not Just Determined by End-Strength

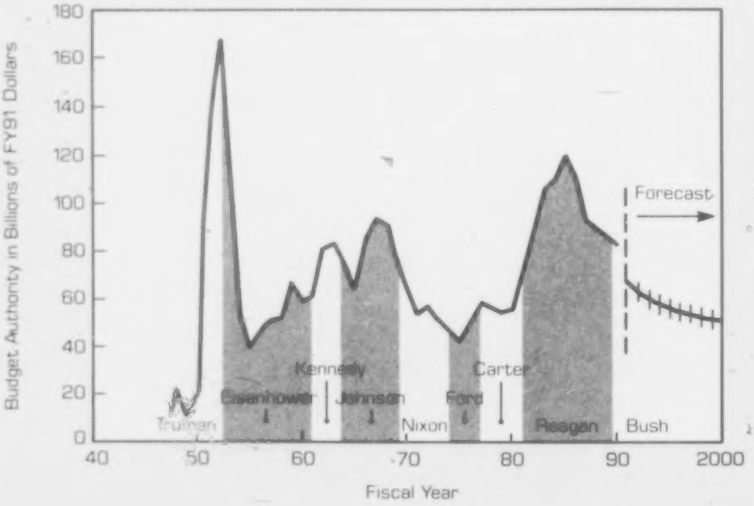
FIGURE 5-H



SOURCE: Electronic Industries Association

Reductions in Procurement Shape the New Force

FIGURE 5-I



SOURCE: Electronic Industries Association

Total DOD Procurement, RDT&E and O&M Electronic Content Forecast Summary (Constant FY 1991 $ Billions)

TABLE 5-8

Program	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Procurement (BA)	33.2	32.4	26.4	24.7	24.0	23.7	23.3	22.3	22.0	21.9	21.9	21.5
RDT&E (BA)	17.1	16.2	15.5	14.5	13.9	13.5	13.1	12.6	12.1	11.8	11.8	11.8
O&M	6.9	6.7	6.4	6.1	5.8	5.6	5.4	5.2	5.1	5.0	5.0	5.0
Total Proc. RDT&E, & O&M	57.2	55.3	48.3	45.3	43.7	42.8	41.8	40.1	39.2	38.7	38.7	38.3
Percent Change	−3.5	−4.5	−12.7	−6.2	−3.5	−2.1	−2.3	−4.1	−2.2	−1.3	0.0	−1.0

Note: Columns may not add due to rounding.
SOURCE: Electronic Industries Association

cost. As overseas bases are closed, savings figures will be even higher. The non-nuclear waste clean-up costs will come from the O&M, the drug interdiction role will largely squeeze other O&M activities and arms control operational activities. On the contrary, the O&M account is not going to track with or fall as significantly as military personnel.

Procurement

In the 1980s the big build-up was related to ship building, the B-1 and the Peacekeeper. Since FY85 we have had a 30% fall in real terms through FY90. Now EIA is forecasting a 20% decline in procurement from FY91, as compared to FY90. It will be proven to be more favorable to buy more slowly and in fewer numbers; and upgrades will be favored over new starts. Hard choices include deciding where production lines will be closed, and which systems will not go through the developmental pipeline to deployment. Second sourcing is dying. The use of non-developmental items and commercial off-the-shelf components will save money and drive procurement costs down.

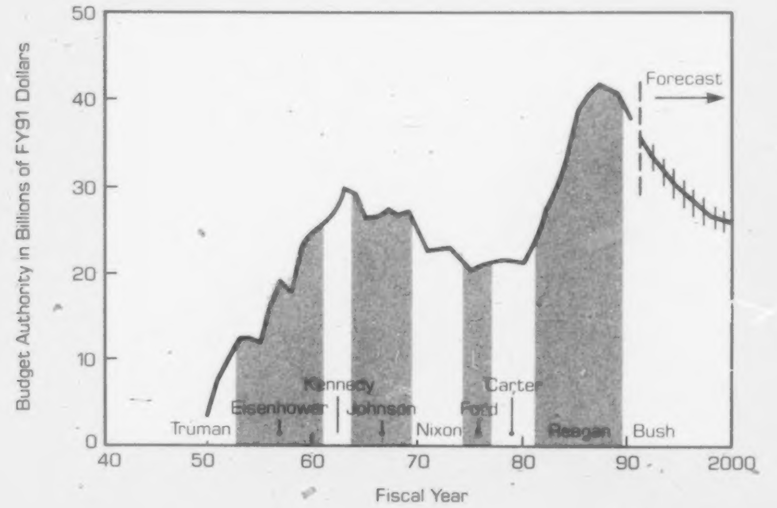
RDT&E

There was a big build-up in RDT&E in the 1980s, due to aircraft programs and SDI. It is now expected to fall, but not back to levels below the 1990s.

The focus will be on the leverage systems: the force multiplier systems; product improvements; the operational systems developmental areas, the fastest growing part of the research arena; and the next generation of Federal Systems Engineering Development (FSED).

RDT&E Remains a Technology Hedge

FIGURE 5-J



SOURCE: Electronic Industries Association

Electronic Content

The decline of the Electronic Content dollars in the early part of the period will decelerate slightly after 1995. The overall procurement plus RDT&E Electronic Content percentage will increase from 40 percent to 43 percent, and electronic content dollars will decline to $33 billion from $42 billion. The growth in Electronic Content percentage is driven by increasing system complexity, increased software costs, demands for multipurpose/multimode capability and increased reliability and maintainability, plus the increasing use of upgrades to existing systems.

Electronic content procurement will downsize from $26.4 billion in 1991 to $21.5 billion in FY 2000. RDT&E is $15.5 billion, declining to $11.8 billion, and O&M electronic content will fall from $6.4 billion to $5.0 billion.

Total electronic content dollars are expected to drop from $48.3 billion to $38.3 billion in the coming decade.

This information was condensed from the Electronic Industries Association (EIA) Government Division/Requirements Committee 26th annual Ten Year Forecast of Defense Electronic Needs. To order a complete report, contact John Geron, 202/457-4944 or Fax 202/457-4985.

6

Electronic-Related Products and Services

The applications of electronics have expanded significantly over recent history, and the impact has been particularly felt by the automotive, aerospace, office equipment and software industries. Electronic-related industries are defined as those which produce products which are partially electronic, or provide services integral to the operation of an electronic product. Products and services discussed in this section include those with electronic features or components which have had a definite impact on the sale of the end product or service. Electronic equipment has been a major factor in the sales growth of at least five other industries, as broken down in Figure 6-B. From 1986 to 1990, U.S. factory sales of electronic-related products and services grew from an estimated $42.6 billion to $54.5 billion, a compound average annual growth rate of almost 7%. U.S. factory sales of electronic-related products and services make up approximately 20% of the total electronic industries sales volume.

Electronics will continue to play an increasing role in the development and sale of products and services from many industries. This chapter has been developed to highlight the broadening applications of electronics in related industries. The range of product areas, as well as their electronic content, will be updated periodically as appropriate. All electronic content estimates made in this chapter are based on a compilation of research from U.S. Department of Commerce publications, other trade associations, and the EIA Marketing Services Research Center.

AEROSPACE

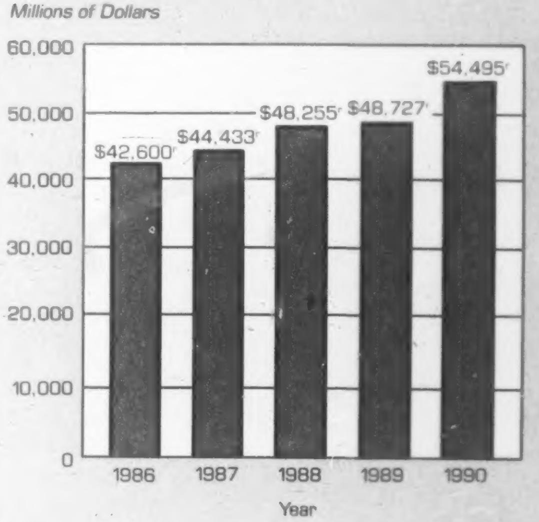
As one of the largest U.S. industries, aerospace makes important contributions to the U.S. economy. It is a major employer and exporter. In the manufacture of its technologically complex, high performance products and systems, it draws upon a wide range of other industries, which contributes to increased employment and speeds the development of technologies in these sectors. Aerospace is the largest component of the defense industry. The *EIA Ten-Year Forecast of Defense Needs* predicts Department of Defense procurements of electronic parts and products will reach $26.4 billion in 1991.

EIA estimates that approximately $27.6 billion of the 1990 dollar value of the aerospace industry represents electronics which are not classified elsewhere in the electronics industries.

According to the *U.S. Industrial Outlook '91*, the aggregate value of aerospace equipment shipments is forecast to grow at a compound average annual growth rate of 3% from 1990 to 1995.

Prospects for U.S. aerospace trade in 1991 are very good. The *U.S. Industrial Outlook '91* predicts that in 1991, the industry will record a trade surplus in excess of $31.8 billion. Foreign customers are expected to purchase $43.0 billion in U.S. aerospace equipment, while imports should register about $11.2 billion.

U.S. Factory Sales of Electronic Related Products/Services 1986-1990 ($ Millions) **FIGURE 6-A**



SOURCE: EIA Marketing Services Department

AUTOMATIC CONTROLS, INDUSTRIAL APPARATUS, AND OTHER INSTRUMENTS

In addition to industrial instruments for measurement (discussed in Chapter 3, Industrial Electronics), automatic controls for regulating residential and commercial environments and appliances, totalizing fluid meters and counting devices, as well as other optical and laboratory instruments, include electronics. Sales of the electronic components or features of these products were estimated to total $1.1 billion in 1990.

SYSTEMS INTEGRATION AND COMPUTER SERVICES

Software programs are the detailed instructions that guide computers through their tasks. Of the three sectors of the software industry—packaged, custom, and integral software—only integral software is not separable from the electronic hardware.

In addition to firms which specialize in providing integrated computer systems data processing services, hardware and peripherals manufacturers, and software developers have found systems integration to be a lucrative business. Although start-up costs are relatively low for these firms, the total number of firms in the business has been relatively stable over the past few years because the number of mergers, acquisitions, and failed businesses has matched the number of new entrants.

The revenues for systems integration software services were estimated to be more than $21 billion last year. EIA estimates that about one-half of total revenues earned were consulting fees and associated services. The growth of systems integration services, in terms of industry revenues, far exceeds the actual sales growth for integral software manufacturers. This is because, over time, the share of equipment costs has declined as the services component of these systems has increased. Repair and maintenance revenues have been going to both software manufacturers and independent contractors/consultants.

The quality and sophistication of U.S. software programs have given the industry a leading position in the world market, with an estimated 60% share. The greatest threat facing U.S. software companies, particularly those in packaged and custom software, is piracy. This problem has effectively kept U.S. software companies out of many foreign markets. As a result, many leading U.S. companies in the computer industry are concentrating on integral systems software and services.

MOTOR VEHICLES

The U.S. motor vehicle industry has had mixed results since its troubled year of the energy crisis in 1979, and the recessionary period in the early eighties. Domestic automobile manufacturers have made dramatic improvements in the quality of their cars, but this measure alone has not stopped the decline in the cumulative market share of the three largest U.S. automakers.

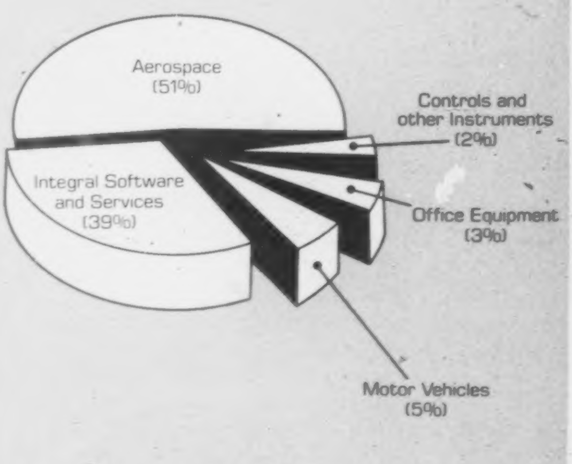
As the automotive market becomes increasingly competitive, U.S. manufacturers are concentrating on incorporating new electronic features to enhance the appeal of their products. New electronic features are appearing predominantly in luxury model cars, but are likely to become standard equipment in mid-range cars during this decade.

EIA estimates that approximately $2.8 billion, of the 1990 dollar value of the U.S. motor vehicle industry, represents electronics which are not classified elsewhere in electronics industries. These electronic products include gadgets such as clocks and trip computers, passive seat belts, and electronic devices for steering, acceleration and braking. Also included in this sector are devices which control suspension, diagnose and fix startup problems, monitor and recall periodic engine trouble and control emissions. Car audio equipment is discussed in Chapter 1, Consumer Electronics.

The Freedonia group predicts that high usage rates of automotive electronics will result from continued product innovations and improvements in performance. By the year 1995, Delco Electronics estimates that electronic content in North America will equal $2,000 per vehicle, compared with $395 in 1987. Although a portion of this value is represented in audio equipment, the majority of automotive electronics (currently about two-thirds) is represented by non-entertainment components such as safety and security products. Freedonia states that the 1990s will witness the introduction of such technologies as rear view CRTs, collision warning/mitigation systems and many other advanced electronics. A hy-

Electronic-Related Products and Service Groups, U.S. Factory Sales; 1990

FIGURE 6-B



Total Sales = $54.5 Billion

SOURCE: EIA Marketing Services Department

brid system using three integrated microprocessors to regulate engine control, vehicle controls and instrumentation is expected to evolve by the early 1990s. Over 40% average annual sales growth is forecast for electronic restraints, and about 30% average annual sales growth for navigational computers, wiper controls and auto security systems.

ELECTRONIC-RELATED OFFICE EQUIPMENT

Electronics has become a significant part of many types of office equipment, not only computers. Computer equipment is discussed in Chapter 3, Computers and Industrial Electronics. Other electronic-related office equipment includes electronic word processors, typewriters, copiers, fax machines, calculators and accounting machines.

In 1990 an estimated 34.3 million Americans regularly worked at home, according to LINK Resources. Consequently, average annual double digit growth is projected for home office sales of copiers, fax machines and printers through 1991. Sales of more mature products such as typewriters, calculators and personal computers are predicted to grow at average annual rates of 5% through 1991.

At-home-workers may be telecommuters or individuals who use the home as an extension of the employer's workplace. They use a wide range of products to enhance productivity, and an estimated 46% own PC's, while 15% own personal copiers and 6% own fax machines. EIA estimates the 1990 U.S. factory sales value of electronics for this market to be $1.7 billion. See Chapter 1 for information on home office equipment.

Electronics and the World Economy

The electronic industries play a significant role in all facets of the world economy. The strength and resilience of the industry are demonstrated in a number of economic arenas including international trade, employment and research and development. In 1990:

- U.S. exports of electronic products rose more than 11.6%, while imports were flat, resulting in a dramatic 54.3% cut in the electronics trade deficit. Approximately 80 countries had at least $10 million in electronics trade with the U.S.
- Employment in the U.S. electronic industries declined 4.7%. Average annual employment in the two largest sectors, components and communications, declined 5.9% and 5.5%, respectively.
- The electronics industries continued to outperform the rest of U.S. industry in funds devoted to research and development, spending about one-sixth of U.S. total industrial R&D funds for 1989.

The role of electronics in each of these areas is discussed below.

INTERNATIONAL TRADE

Total trade in electronics (imports plus exports) topped $151.7 billion in 1990, a 5.5% increase over 1989 trade of $143.8 billion. Exports totaled $72.8 billion in 1990, an increase of 11.6%, while imports of electronic products increased a slight 0.4% to $78.9 billion. The reported trade totals actually underestimate total trade in electronics, as the electronic content in such equipment as airplanes, machine tools, motor vehicles, and other electronically-controlled capital equipment is not separately identified in trade statistics and therefore is not included in electronics trade statistics. U.S. trade in electronics produced a deficit of $6.1 billion in 1990, a figure 54.3% less than the $13.4 billion deficit recorded in 1989. The large decrease in the electronics trade deficit is attributed to the vastly expanding solid state and computer/industrial products export markets.

In order to reduce the trade deficit even further, U.S. industry must continue to look beyond domestic markets. With a recession in the domestic economy, firms must look to other countries for sources of sales growth. Yet, with dramatic changes occurring all over the world this is a difficult task.

Imports

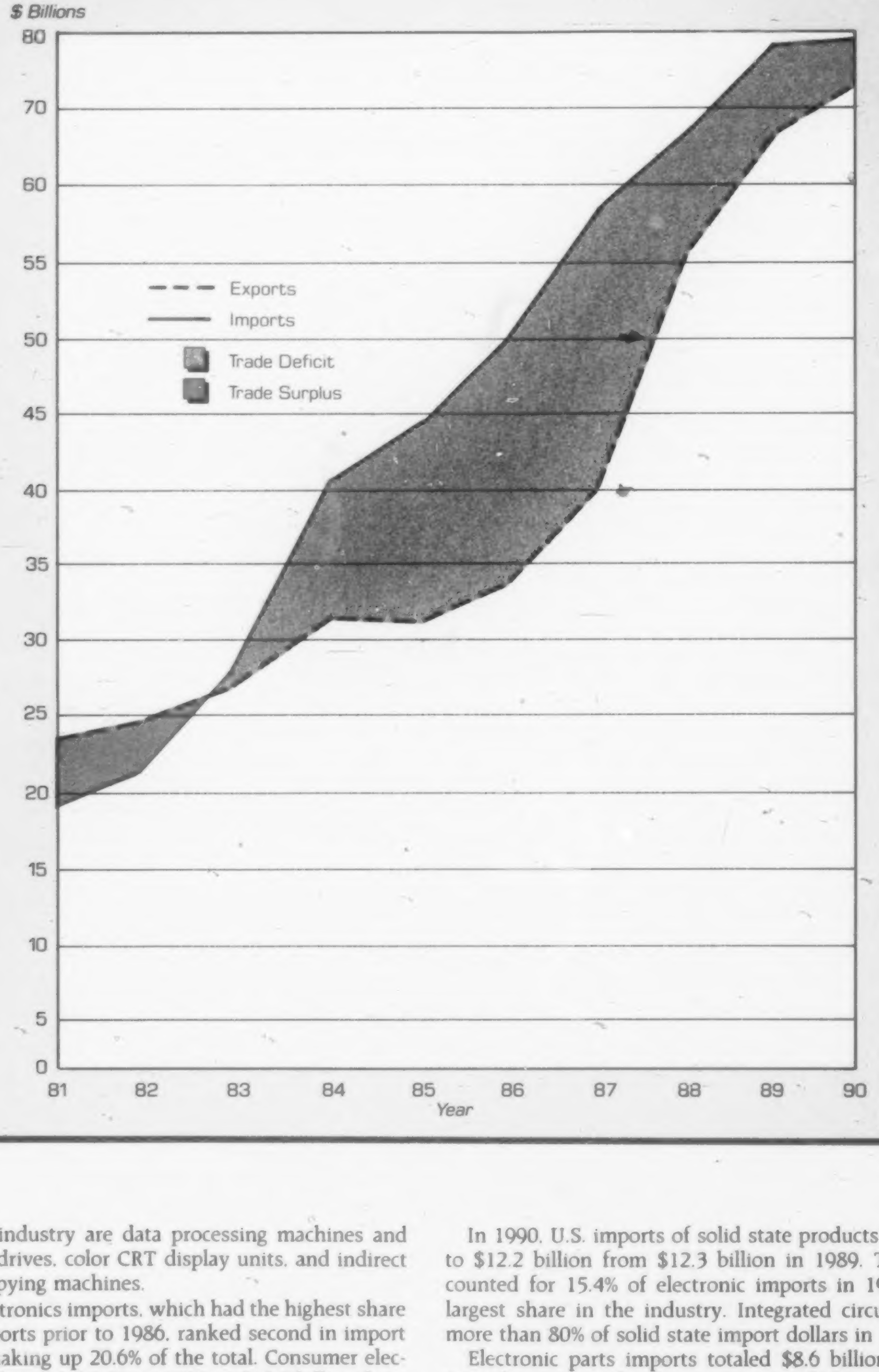
U.S. imports of electronic products increased at an average annual rate of 12.1% during the last four years, rising from $50.4 billion in 1986 to $78.9 billion in 1990 (see Table 7-1). Since 1986, computer/industrial products have made up the largest share of electronic imports, representing 41.2% in 1990 (see Figure 7-B). Computer/industrial imports registered a slight increase of 1.9% in 1990 to $32.5 billion. The leading

Imports of Electronic Products by Industry ($ Thousands); United States, 1986-1990 **TABLE 7-1**

PRODUCT GROUP	1986	1987	1988	1989	1990
Communications Products	4,944,379	5,710,660	6,532,568	8,409,120	8,573,014
Consumer Electronics	15,722,093	15,163,224	15,910,719	16,789,260	16,236,184
Electron Tubes	474,256	492,042	585,142	852,534	821,812
Electronic Parts	6,222,830	7,340,776	8,584,080	8,335,485	8,589,113
Computer/Industrial	17,036,530	21,526,356	26,180,351	31,893,447	32,488,996
Solid State Products	5,962,529	7,617,913	10,802,590	12,303,856	12,183,497
TOTAL[1]	50,362,717	57,850,972	68,595,450	78,583,700	78,892,617

[1] Totals may not equal due to rounding.
SOURCE: U.S. Department of Commerce.

Imports, Exports and Balance of Trade for Electronic Products ($ Billions); United States, 1981-1990 **FIGURE 7-A**



imports in this industry are data processing machines and parts, hard disc drives, color CRT display units, and indirect process office copying machines.

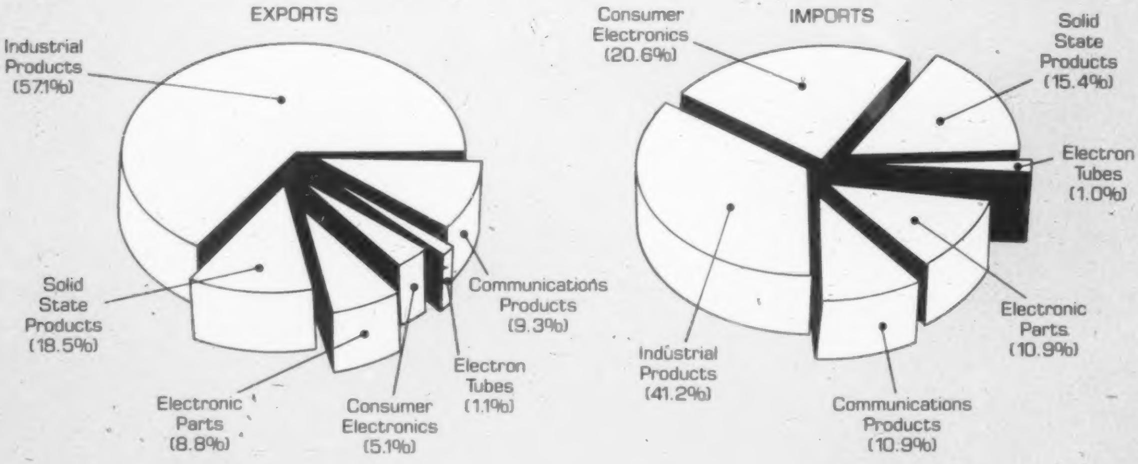
Consumer electronics imports, which had the highest share of electronic imports prior to 1986, ranked second in import share in 1990, making up 20.6% of the total. Consumer electronics imports decreased 3.3% in 1990 to $16.2 billion from $16.8 million in 1989. Videocassette recorders (VCRs) accounted for 14.1% of dollar volume in this sector in 1990, followed by camcorders (10.5%), color televisions (8.8%), and video games (6.1%).

In 1990, U.S. imports of solid state products dropped 1.0% to $12.2 billion from $12.3 billion in 1989. The sector accounted for 15.4% of electronic imports in 1990, the third largest share in the industry. Integrated circuits composed more than 80% of solid state import dollars in 1990.

Electronic parts imports totaled $8.6 billion in 1990, up 3.1% from 1989. Leading imports include printed circuits, power supplies, connectors, and circuit boards and subassemblies for color TV.

Communications imports rose only 2% in 1990 to $8.6 billion. Facsimile machines, telephone sets, and cordless tele-

Percentage Share of Imports/Exports by Industry, 1990 **FIGURE 7-B**



Total: $72.8 Billion **Total: $78.9 Billion**

SOURCE: Tables 7-1 and 7-2

phones led in dollar volume, accounting for 23.8% of communications imports.

Electron tubes, which made up 1.0% of electronic imports in 1990, decreased 3.6% to $822 million. Cathode ray tubes (CRTs) and parts of CRTs led imports in this sector, followed by X-ray tubes and large (20" and over) color television picture tubes.

Exports

U.S. exports of electronics increased in 1990, rising 11.6% to $72.8 billion. The consumer electronics and electronic parts sectors experienced the highest growth rate at 26.6% each.

As with imports, computer/industrial products made up the largest share of electronic exports, accounting for 57.1% of the total. Exports of computer/industrial products rose 9.9% in 1990 to $41.6 billion. Computer equipment and business machines accounted for 65.9% of export dollar volume, making these products the number one electronic export in 1990.

Exports of solid state products increased 12.9% to $13.5 billion in 1990, from $11.9 billion in 1989 and comprised 18.5% of total electronic exports. Integrated circuits were the leading export, totaling 83.3% of solid state export dollar volume.

Communications exports, which had the third largest share of electronic exports in 1990, increased 1.1% from 1989 to $6.8 billion. The leading exports in this sector were telephone equipment (25%) and radio/radar navigational equipment (18.8%).

U.S. exports of electronic parts topped $6.4 billion in 1990. After falling nearly 6% in 1985, exports of electronic parts have rebounded strongly, increasing an average of more than 20% annually from 1986 to 1990. Products primarily responsible for the recovery include printed circuit boards, television apparatus and parts, and connectors.

Consumer electronics exports jumped 26.6% from 1989 to 1990 to $3.7 billion, following a 9.3% gain in 1989. Color television receivers and blank video tape led consumer electronics exports.

Electron tube exports totaled $776 million in 1990, a 13.2% increase from 1989. Color television picture tubes were the primary tube type exported in 1990.

Balance of Trade

The electronics trade deficit decreased 54% in 1990 to $6.1 billion. This remarkable drop is attributed to the vastly expanding computer/industrial and solid state products exports (see Table 7-3).

The computer/industrial electronics trade surplus increased dramatically, rising to $9.1 billion in 1990 from $5.9 billion in 1989. The solid state products sector showed a surplus of $1.3 billion in 1990, up from a $358 million deficit in 1989. The electron tubes trade deficit decreased 72.8% to $45 million. The trade deficits for electronic parts and consumer electronics declined 33.4% and 9.7%, respectively. The communications sector registered a 5.5% increase in its trade deficit.

U.S. Trade Partners

The United States is a major trading partner for most of the world, supplying more than 110 countries with consumer electronics products alone. Import, export, and trade balance data are presented in Table 7-4 for the countries whose total trade in electronics with the U.S. (exports plus imports) exceeded $10 million in 1990.

Exports of Electronic Products by Industry ($ Thousands); United States, 1986-1990

TABLE 7-2

PRODUCT GROUP	1986	1987	1988	1989	1990
Communications Products	3,323,733	3,795,933	5,149,674	6,723,808	6,795,912
Consumer Electronics	1,166,130	1,546,994	2,709,096	2,959,652	3,747,483
Electron Tubes	425,881	409,888	604,717	685,847	776,471
Electronic Parts	2,742,976	3,348,980	4,594,077	5,062,110	6,407,236
Computer/Industrial	20,921,423	24,705,425	32,701,108	37,814,526	41,561,898
Solid State Products	4,870,971	6,231,145	9,754,079	11,946,200	13,481,798
TOTAL[1]	33,451,115	40,038,366	55,512,750	65,192,144	72,770,797

[1] Totals may not equal due to rounding.
SOURCE: U.S. Department of Commerce.

Asian countries continue to dominate the "Top 10" list of U.S. trade partners, with Japan keeping its position as the nation's number one trading partner in electronics. In 1990, Japan supplied the U.S. with $30.6 billion in imports, a decrease of 4.1% from 1989, more than four times greater than the next leading supplier, Singapore, which had exports to the U.S. of $6.9 million. Others in the top ten include Taiwan ($6.3 billion), South Korea ($5.6 billion), Mexico ($5.4 billion), Canada ($5.4 billion), Malaysia ($3.2 billion), West Germany ($2.6 billion), Hong Kong ($2.0 billion), and the United Kingdom ($2.0 billion).

Canada maintained its rank as the number one market for U.S. electronic products with 1990 imports of $12.5 billion. Japan remained in second place purchasing $8.4 billion in U.S. exports, followed by the United Kingdom at $6.2 billion. The remaining top markets for U.S. exports in 1990 were: West Germany ($5.2 billion), Mexico ($5.0 billion), Singapore ($3.4 billion), the Netherlands ($3.2 billion), France ($3.1 billion), South Korea ($2.7 billion), and Taiwan ($2.5 billion). A complete listing of the top 10 suppliers and markets for U.S. electronics imports and exports appears in Table 7-5.

Communications Products

The communications sector registered a trade deficit of $1.78 billion in 1990. As indicated in Table 7-6, which lists the top ten markets for U.S. electronic products by industry group and the top ten suppliers of electronic products to the United States, Japan accounted for almost 34.0% of communications imports in 1990. The top ten importers accounted for 87.3% of total communications imports in 1990.

U.S. exports of communications products rose slightly in 1990 to $6.8 million. Canada was the number one destination for U.S. communications products, taking in $850 million, or 12.6% of the total. Other leading export markets were Mexico and Japan, each accounting for more than 11.0% of the total. U.S. exports of communications products are less heavily concentrated in the top ten markets than imports: in 1990 the top ten markets accounted for 66.6% of communications exports.

Consumer Electronics

The consumer electronics trade balance continues to make up the lion's share of the U.S. trade deficit in electronics: imports of consumer electronics products exceeded exports by more than four times in 1990.

In 1990, Japan supplied $9 billion in consumer electronics products to the U.S., or 55.5% of the total. South Korea followed Japan with 10.0% of the market, and Mexico, primarily on the strength of color television sets, edged Taiwan as the

Balance of Trade for Electronic Products by Industry ($ Thousands); United States, 1986-1990

TABLE 7-3

PRODUCT GROUP	1986	1987	1988	1989	1990
Communications Products	(1,620,646)	(1,914,727)	(1,382,894)	(1,685,311)	(1,777,102)
Consumer Electronics	(14,555,963)	(13,616,231)	(13,201,624)	(13,829,607)	(12,488,702)
Electron Tubes	(48,375)	(82,154)	(19,575)	(166,687)	(45,341)
Electronic Parts	(3,479,853)	(3,991,795)	(3,990,004)	(3,273,375)	(2,181,877)
Computer/Industrial	3,844,893	3,179,069	6,520,757	5,921,079	9,072,901
Solid State Products	(1,091,658)	(1,386,768)	(1,048,511)	(357,656)	1,298,301
TOTAL[1]	(16,911,602)	(17,812,606)	(13,082,700)	(13,391,556)	(6,121,819)

[1] Totals may not equal due to rounding.
SOURCE: U.S. Department of Commerce.

Balance of Trade for Electronic Products by Industry and Country ($ Millions); United States, 1990

TABLE 7-4

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
ALGERIA			
Communication Products	2.1	0.0	2.1
Consumer Electronics	0.2	0.0	0.2
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.7	0.0	0.7
Computer/Industrial	22.8	0.0	22.8
Solid State Products	0.3	0.0	0.3
TOTALS	26.1	0.0	26.1
ANGOLA			
Communication Products	1.7	0.0	1.7
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.2	0.0	0.2
Electronic Parts	0.9	0.0	0.9
Computer/Industrial	7.7	0.0	7.7
Solid State Products	0.2	0.0	0.2
TOTALS	10.8	0.0	10.8
ARGENTINA			
Communication Products	23.4	0.4	23.0
Consumer Electronics	13.5	0.0	13.5
Electron Tubes	1.0	0.0	1.0
Electronic Parts	12.2	1.1	11.1
Computer/Industrial	185.2	6.2	178.9
Solid State Products	8.4	0.0	8.4
TOTALS	243.7	7.7	235.9
ARUBA			
Communication Products	2.0	0.0	2.0
Consumer Electronics	2.6	0.0	2.6
Electron Tubes	0.1	0.0	0.1
Electronic Parts	0.8	0.0	0.8
Computer/Industrial	6.8	0.0	6.8
Solid State Products	0.1	0.0	0.1
TOTALS	12.4	0.0	12.4
AUSTRALIA			
Communication Products	111.5	23.3	88.2
Consumer Electronics	64.0	2.4	61.6
Electron Tubes	16.7	0.0	16.7
Electronic Parts	62.2	2.9	59.3
Computer/Industrial	1 255.5	76.1	1 179.4
Solid State Products	71.4	5.9	65.5
TOTALS	1 581.3	110.6	1 470.7
AUSTRIA			
Communication Products	16.3	6.5	9.8
Consumer Electronics	8.2	17.2	9.0
Electron Tubes	6.4	4.9	1.5
Electronic Parts	13.2	8.1	5.1
Computer/Industrial	202.9	50.8	152.1
Solid State Products	17.9	12.8	5.1
TOTALS	264.9	100.3	164.6
BAHAMAS			
Communication Products	4.1	0.0	4.1
Consumer Electronics	2.7	0.0	2.7
Electron Tubes	0.1	0.0	0.1
Electronic Parts	2.7	0.0	2.7
Computer/Industrial	10.9	0.2	10.7
Solid State Products	0.2	0.2	0.0
TOTALS	20.7	0.4	20.3
BAHRAIN			
Communication Products	4.0	0.0	4.0
Consumer Electronics	0.4	0.0	0.4
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.5	0.0	0.5
Computer/Industrial	17.7	0.1	17.6
Solid State Products	0.4	0.0	0.4
TOTALS	23.0	0.1	22.9
BARBADOS			
Communication Products	2.6	0.8	1.8
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	0.0	0.0	0.0
Electronic Parts	4.2	9.7	5.5
Computer/Industrial	8.4	1.3	7.1
Solid State Products	0.4	0.0	0.4
TOTALS	16.7	11.8	4.9
BELGIUM			
Communication Products	44.3	7.7	36.6
Consumer Electronics	22.1	25.6	3.5
Electron Tubes	3.7	0.2	3.5
Electronic Parts	44.1	24.0	20.0
Computer/Industrial	632.6	58.6	574.0
Solid State Products	35.3	2.2	33.1
TOTALS	782.1	118.3	663.7
BELIZE			
Communication Products	4.7	0.0	4.7
Consumer Electronics	3.7	0.0	3.7
Electron Tubes	0.0	0.0	0.0
Electronic Parts	1.0	0.0	1.0
Computer/Industrial	4.7	0.0	4.6
Solid State Products	0.1	0.0	0.1
TOTALS	14.2	0.0	14.1
BERMUDA			
Communication Products	3.1	0.0	3.1
Consumer Electronics	[illegible]	0.0	1.8
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.5	0.0	0.5
Computer/Industrial	12.4	0.2	12.2
Solid State Products	0.1	0.0	0.1
TOTALS	17.9	0.2	17.7
BOLIVIA			
Communication Products	7.1	0.0	7.1
Consumer Electronics	0.3	0.0	0.3
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.4	0.0	0.4
Computer/Industrial	14.0	0.0	14.0
Solid State Products	0.0	0.0	0.0
TOTALS	21.8	0.0	21.8
BRAZIL			
Communication Products	255.0	3.7	251.3
Consumer Electronics	45.0	104.0	59.1
Electron Tubes	44.9	11.3	33.6
Electronic Parts	51.1	69.2	18.1
Computer/Industrial	565.3	70.4	495.0
Solid State Products	122.3	6.0	116.4
TOTALS	1 083.6	264.6	819.1
BRUNEI			
Communication Products	6.2	0.0	6.2
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.4	0.0	0.4
Computer/Industrial	7.4	0.0	7.4
Solid State Products	0.0	0.0	0.0
TOTALS	14.1	0.0	14.1
CANADA			
Communication Products	849.8	878.5	28.7
Consumer Electronics	749.0	105.3	643.7
Electron Tubes	74.9	14.9	60.0
Electronic Parts	2 325.3	1 030.3	1 295.0
Computer/Industrial	6 311.0	2 315.4	3 995.6
Solid State Products	2 159.3	1 007.0	1 152.3
TOTALS	12 469.3	5 351.4	7 117.9
CHILE			
Communication Products	40.1	0.0	40.1
Consumer Electronics	15.0	0.0	15.0
Electron Tubes	1.0	0.0	1.0
Electronic Parts	7.9	0.1	7.8
Computer/Industrial	116.6	0.2	116.4
Solid State Products	1.8	0.0	1.8
TOTALS	182.4	0.3	182.1
CHINA (MAINLAND)			
Communication Products	69.9	488.7	418.8
Consumer Electronics	7.8	859.0	851.2
Electron Tubes	15.3	3.5	11.8
Electronic Parts	25.3	113.1	87.8
Computer/Industrial	392.2	171.3	220.9
Solid State Products	18.5	1.3	17.2
TOTALS	529.0	1 636.9	1 107.9
COLOMBIA			
Communication Products	37.0	0.2	36.8
Consumer Electronics	16.3	0.0	16.3
Electron Tubes	1.8	0.0	1.8
Electronic Parts	7.2	1.1	6.1
Computer/Industrial	150.7	0.4	150.4
Solid State Products	3.9	0.0	3.9
TOTALS	216.9	1.7	215.3
COSTA RICA			
Communication Products	9.0	0.6	8.4
Consumer Electronics	5.6	0.9	4.7
Electron Tubes	0.2	0.0	0.2
Electronic Parts	17.8	17.3	0.4
Computer/Industrial	37.3	0.6	36.7
Solid State Products	2.6	0.4	2.1
TOTALS	72.5	19.8	52.5
CYPRUS			
Communication Products	10.5	0.0	10.5
Consumer Electronics	0.3	0.0	0.3
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.3	0.0	0.3
Computer/Industrial	5.8	0.0	5.7
Solid State Products	0.2	0.0	0.2
TOTALS	17.1	0.0	17.0
CZECHOSLOVAKIA			
Communication Products	0.6	0.0	0.6
Consumer Electronics	1.2	0.0	1.2
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.7	0.0	0.7
Computer/Industrial	20.3	0.2	20.1
Solid State Products	0.1	0.0	0.1
TOTALS	22.9	0.2	22.7
DENMARK			
Communication Products	25.1	17.9	7.2
Consumer Electronics	34.8	13.8	20.9
Electron Tubes	1.2	0.4	0.8
Electronic Parts	14.7	23.8	9.1
Computer/Industrial	173.4	68.8	104.7
Solid State Products	12.9	2.9	10.0
TOTALS	262.1	127.6	134.5
DOMINICAN REPUBLIC			
Communication Products	12.1	2.0	10.1
Consumer Electronics	3.0	0.0	2.9
Electron Tubes	0.1	0.0	0.1
Electronic Parts	25.0	35.4	10.3
Computer/Industrial	37.2	12.6	24.5
Solid State Products	1.0	0.3	0.8
TOTALS	78.4	50.3	28.1

(Continued)

TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
ECUADOR			
Communication Products	9.2	0.0	9.2
Consumer Electronics	8.0	0.0	8.0
Electron Tubes	0.3	0.0	0.3
Electronic Parts	3.3	0.0	3.3
Computer/Industrial	32.5	0.1	32.4
Solid State Products	0.6	0.0	0.6
TOTALS	53.9	0.1	53.8
EGYPT			
Communication Products	91.4	0.0	91.4
Consumer Electronics	2.2	0.0	2.2
Electron Tubes	1.5	0.0	1.5
Electronic Parts	10.7	0.0	10.7
Computer/Industrial	120.0	0.0	119.9
Solid State Products	3.3	0.0	3.3
TOTALS	229.1	0.0	229.0
EL SALVADOR			
Communication Products	10.1	0.0	10.0
Consumer Electronics	2.0	0.0	2.0
Electron Tubes	0.1	0.0	0.1
Electronic Parts	22.8	24.4	-1.6
Computer/Industrial	14.1	0.2	13.8
Solid State Products	0.4	0.0	0.4
TOTALS	49.5	24.6	24.7
FEDERAL REPUBLIC OF GERMANY			
Communication Products	301.4	109.9	191.5
Consumer Electronics	243.2	127.8	115.4
Electron Tubes	50.4	84.0	-33.6
Electronic Parts	257.9	414.1	-156.2
Computer/Industrial	3,909.6	1,537.0	2,372.6
Solid State Products	476.1	300.6	175.5
TOTALS	5,238.6	2,573.4	2,665.2
FINLAND			
Communication Products	14.2	4.3	9.9
Consumer Electronics	7.4	0.0	7.4
Electron Tubes	5.7	0.0	5.7
Electronic Parts	18.2	22.3	-4.1
Computer/Industrial	176.6	77.3	99.3
Solid State Products	15.3	2.2	13.1
TOTALS	237.4	106.1	131.3
FRANCE			
Communication Products	171.8	105.4	66.4
Consumer Electronics	76.5	12.1	64.4
Electron Tubes	31.3	31.3	0.0
Electronic Parts	188.0	89.1	98.8
Computer/Industrial	2,170.0	496.9	1,673.1
Solid State Products	411.7	178.4	233.3
TOTALS	3,049.3	913.2	2,136.0
GREECE			
Communication Products	10.4	1.7	8.7
Consumer Electronics	5.1	0.0	5.1
Electron Tubes	0.4	0.0	0.4
Electronic Parts	1.7	0.4	1.3
Computer/Industrial	38.0	1.4	36.6
Solid State Products	0.6	0.0	0.6
TOTALS	56.2	3.5	52.7
GUATEMALA			
Communication Products	6.4	0.0	6.4
Consumer Electronics	7.0	0.0	7.0
Electron Tubes	0.5	0.0	0.5
Electronic Parts	4.7	0.0	4.7
Computer/Industrial	22.6	0.0	22.5
Solid State Products	0.3	0.0	0.3
TOTALS	41.5	0.0	41.4
HAITI			
Communication Products	3.0	0.7	2.3
Consumer Electronics	3.5	0.0	3.5
Electron Tubes	4.6	0.0	4.6
Electronic Parts	13.6	18.2	-4.7
Computer/Industrial	10.0	2.6	7.5
Solid State Products	0.4	0.4	0.0
TOTALS	35.1	21.9	13.2
HONDURAS			
Communication Products	8.7	0.0	8.7
Consumer Electronics	1.7	0.0	1.7
Electron Tubes	0.0	0.0	0.0
Electronic Parts	4.2	0.0	4.2
Computer/Industrial	12.2	0.0	12.2
Solid State Products	0.2	0.0	0.2
TOTALS	27.0	0.0	27.0
HONG KONG			
Communication Products	118.7	356.1	-237.4
Consumer Electronics	71.0	254.3	-183.3
Electron Tubes	7.0	0.4	5.5
Electronic Parts	117.6	299.2	-181.5
Computer/Industrial	534.4	828.6	-294.2
Solid State Products	756.0	263.4	492.6
TOTALS	1,604.7	2,002.0	-397.3
HUNGARY			
Communication Products	2.1	0.0	2.1
Consumer Electronics	1.7	0.0	1.7
Electron Tubes	0.3	0.1	0.2
Electronic Parts	1.1	0.1	1.0
Computer/Industrial	19.8	2.1	17.7
Solid State Products	0.6	0.1	0.5
TOTALS	25.6	2.4	23.2
INDIA			
Communication Products	28.0	1.0	27.0
Consumer Electronics	5.6	1.5	4.1
Electron Tubes	4.7	0.0	4.7
Electronic Parts	24.8	4.7	20.1
Computer/Industrial	227.1	3.4	223.7
Solid State Products	39.1	4.9	34.2
TOTALS	329.3	15.5	313.8
INDONESIA			
Communication Products	37.5	5.2	32.3
Consumer Electronics	3.4	7.4	-4.0
Electron Tubes	0.5	0.0	0.5
Electronic Parts	7.7	2.4	5.3
Computer/Industrial	107.3	0.4	106.9
Solid State Products	12.9	13.8	-0.9
TOTALS	169.3	29.2	140.1
IRAN			
Communication Products	1.8	0.0	1.8
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.1	0.0	0.1
Computer/Industrial	16.6	0.4	16.2
Solid State Products	0.3	0.0	0.3
TOTALS	18.9	0.4	18.5
IRAQ			
Communication Products	1.7	0.0	1.7
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.3	0.0	0.3
Electronic Parts	1.1	0.0	1.1
Computer/Industrial	16.5	0.0	16.5
Solid State Products	0.1	0.0	0.1
TOTALS	19.8	0.0	19.8
IRELAND			
Communication Products	15.3	10.6	4.7
Consumer Electronics	21.6	3.3	18.3
Electron Tubes	0.1	0.0	0.1
Electronic Parts	80.5	32.7	47.8
Computer/Industrial	730.5	303.5	427.1
Solid State Products	127.5	75.5	52.0
TOTALS	975.5	425.6	550.0
ISRAEL			
Communication Products	166.1	150.7	15.4
Consumer Electronics	15.2	2.6	12.7
Electron Tubes	6.8	0.4	6.4
Electronic Parts	46.9	42.7	4.3
Computer/Industrial	340.1	250.0	90.1
Solid State Products	92.8	100.1	-7.3
TOTALS	667.9	546.5	121.6
ITALY			
Communication Products	163.8	33.9	129.9
Consumer Electronics	64.0	18.2	45.9
Electron Tubes	18.4	10.7	7.7
Electronic Parts	111.8	46.4	65.4
Computer/Industrial	1,206.9	356.1	850.8
Solid State Products	208.2	49.9	158.3
TOTALS	1,773.1	515.2	1,258.0
JAMAICA			
Communication Products	9.7	0.1	9.6
Consumer Electronics	2.5	0.0	2.5
Electron Tubes	0.1	0.0	0.1
Electronic Parts	5.9	1.2	4.7
Computer/Industrial	18.3	0.1	18.2
Solid State Products	0.7	0.0	0.7
TOTALS	37.2	1.4	35.8
JAPAN			
Communication Products	747.8	2,907.6	-2,159.8
Consumer Electronics	283.4	9,017.5	-8,734.1
Electron Tubes	103.1	453.3	-350.3
Electronic Parts	297.8	1,970.5	-1,672.7
Computer/Industrial	5,555.0	12,987.1	-7,432.1
Solid State Products	1,367.5	3,286.1	-1,918.6
TOTALS	8,354.6	30,622.1	-22,267.6
JORDAN			
Communication Products	9.2	0.0	9.2
Consumer Electronics	0.4	0.0	0.4
Electron Tubes	0.3	0.0	0.3
Electronic Parts	1.1	0.0	1.1
Computer/Industrial	6.0	0.1	5.9
Solid State Products	0.2	0.0	0.2
TOTALS	17.2	0.1	17.1
SOUTH KOREA			
Communication Products	231.0	547.0	-316.0
Consumer Electronics	46.4	1,641.4	-1,594.9
Electron Tubes	27.9	14.6	13.3
Electronic Parts	85.9	218.5	-132.6
Computer/Industrial	1,278.2	1,391.9	-113.7
Solid State Products	1,040.6	1,763.2	-722.6
TOTALS	2,710.0	5,576.6	-2,866.5
KUWAIT			
Communication Products	6.0	0.0	6.0
Consumer Electronics	1.4	0.0	1.4
Electron Tubes	0.1	0.0	0.1
Electronic Parts	3.3	0.0	3.3
Computer/Industrial	22.7	0.0	22.7
Solid State Products	0.1	0.0	0.1
TOTALS	33.6	0.0	33.6

(Continued)

TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
LUXEMBOURG			
Communication Products	6.6	0.0	6.6
Consumer Electronics	0.9	0.0	0.9
Electron Tubes	0.5	0.0	0.5
Electronic Parts	0.5	0.2	0.3
Computer/Industrial	6.6	0.5	6.1
Solid State Products	0.5	0.0	0.5
TOTALS	15.6	0.7	14.9
MALAYSIA			
Communication Products	44.2	429.2	-384.9
Consumer Electronics	4.2	720.3	-716.1
Electron Tubes	0.3	0.0	0.3
Electronic Parts	32.9	204.5	-171.6
Computer/Industrial	283.7	194.7	89.1
Solid State Products	1,680.9	1,658.1	22.9
TOTALS	2,046.2	3,206.8	-1,160.3
MALTA AND GOZO			
Communication Products	0.3	0.0	0.3
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.1	0.3	0.2
Computer/Industrial	5.7	0.1	5.6
Solid State Products	0.7	16.9	16.2
TOTALS	6.9	17.3	-10.4
MEXICO			
Communication Products	798.0	467.6	330.4
Consumer Electronics	560.9	1,387.6	-826.8
Electron Tubes	191.7	51.5	140.3
Electronic Parts	1,309.2	2,144.2	-835.1
Computer/Industrial	1,698.8	975.1	723.6
Solid State Products	458.9	361.1	97.8
TOTALS	5,017.5	5,387.1	-369.8
MOROCCO			
Communication Products	12.8	0.0	12.8
Consumer Electronics	0.5	0.1	0.4
Electron Tubes	0.3	0.0	0.3
Electronic Parts	10.6	0.0	10.6
Computer/Industrial	3.8	0.0	3.8
Solid State Products	0.3	15.5	-15.2
TOTALS	28.3	15.6	12.7
NETHERLANDS			
Communication Products	114.2	60.7	53.5
Consumer Electronics	207.8	11.4	196.4
Electron Tubes	21.5	19.2	2.3
Electronic Parts	96.8	25.6	71.2
Computer/Industrial	2,600.2	433.1	2,167.1
Solid State Products	141.6	23.4	118.2
TOTALS	3,182.1	573.4	2,608.7
NETHERLANDS ANTILLES			
Communication Products	5.8	0.0	5.8
Consumer Electronics	7.0	0.0	7.0
Electron Tubes	0.0	0.0	0.0
Electronic Parts	1.1	0.4	0.7
Computer/Industrial	13.7	0.0	13.6
Solid State Products	1.8	0.0	1.8
TOTALS	29.4	0.4	28.9
NEW ZEALAND			
Communication Products	24.5	0.8	23.7
Consumer Electronics	7.8	0.0	7.8
Electron Tubes	1.0	0.0	1.0
Electronic Parts	6.5	0.3	6.2
Computer/Industrial	138.3	4.3	134.0
Solid State Products	3.2	0.0	3.2
TOTALS	181.3	5.4	175.9
NIGERIA			
Communication Products	16.5	0.0	16.5
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	0.4	0.0	0.4
Electronic Parts	1.3	0.0	1.3
Computer/Industrial	36.1	0.1	36.1
Solid State Products	0.5	0.0	0.5
TOTALS	55.9	0.1	55.9
NORWAY			
Communication Products	36.8	9.6	27.2
Consumer Electronics	8.1	0.5	7.6
Electron Tubes	2.5	0.0	2.5
Electronic Parts	14.0	3.6	10.4
Computer/Industrial	182.4	49.4	133.0
Solid State Products	10.7	1.0	9.7
TOTALS	254.5	64.1	190.4
OMAN			
Communication Products	10.5	0.0	10.5
Consumer Electronics	0.5	0.0	0.5
Electron Tubes	0.0	0.0	0.0
Electronic Parts	1.6	0.0	1.6
Computer/Industrial	12.7	0.0	12.7
Solid State Products	0.2	0.0	0.2
TOTALS	25.5	0.0	25.5
PAKISTAN			
Communication Products	9.2	0.0	9.2
Consumer Electronics	0.9	0.0	0.9
Electron Tubes	1.7	0.0	1.7
Electronic Parts	1.4	0.0	1.4
Computer/Industrial	29.8	7.2	22.6
Solid State Products	0.4	0.0	0.4
TOTALS	43.4	7.2	36.2
PANAMA			
Communication Products	9.7	0.0	9.7
Consumer Electronics	39.8	0.2	39.6
Electron Tubes	0.2	0.0	0.2
Electronic Parts	5.7	0.0	5.7
Computer/Industrial	24.8	0.2	24.6
Solid State Products	0.3	0.0	0.3
TOTALS	80.5	0.4	80.1
PARAGUAY			
Communication Products	41.8	0.0	41.8
Consumer Electronics	50.6	0.0	50.6
Electron Tubes	0.1	0.0	0.1
Electronic Parts	2.9	0.0	2.9
Computer/Industrial	50.5	0.0	50.5
Solid State Products	2.2	0.0	2.2
TOTALS	148.1	0.0	148.1
PERU			
Communication Products	12.5	0.0	12.5
Consumer Electronics	3.3	0.0	3.3
Electron Tubes	0.3	0.0	0.3
Electronic Parts	2.0	12.3	10.3
Computer/Industrial	37.2	0.4	36.8
Solid State Products	1.4	0.0	1.4
TOTALS	56.7	12.7	44.0
PHILIPPINES			
Communication Products	33.3	177.1	143.8
Consumer Electronics	14.9	40.5	25.5
Electron Tubes	0.8	0.0	0.8
Electronic Parts	37.7	19.9	17.8
Computer/Industrial	108.6	77.9	30.7
Solid State Products	582.8	566.3	16.4
TOTALS	778.1	881.7	103.6
POLAND			
Communication Products	5.9	0.0	5.9
Consumer Electronics	3.7	0.1	3.6
Electron Tubes	0.7	0.5	0.2
Electronic Parts	1.1	0.3	0.8
Computer/Industrial	23.1	0.1	23.0
Solid State Products	0.8	0.2	0.5
TOTALS	35.3	1.2	34.0
PORTUGAL			
Communication Products	19.0	0.2	18.8
Consumer Electronics	1.8	1.9	-0.1
Electron Tubes	3.7	0.0	3.7
Electronic Parts	4.5	9.2	-4.7
Computer/Industrial	76.8	21.5	55.3
Solid State Products	29.3	8.7	20.6
TOTALS	135.1	41.5	93.6
QATAR			
Communication Products	3.6	0.0	3.6
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	0.0	0.0	0.0
Electronic Parts	0.7	0.0	0.7
Computer/Industrial	9.7	0.0	9.7
Solid State Products	0.0	0.0	0.0
TOTALS	15.1	0.0	15.1
REPUBLIC OF SOUTH AFRICA			
Communication Products	19.5	0.1	19.4
Consumer Electronics	9.2	0.1	9.1
Electron Tubes	1.1	0.0	1.1
Electronic Parts	14.8	0.2	14.6
Computer/Industrial	212.4	1.7	210.7
Solid State Products	12.6	0.0	12.6
TOTALS	269.6	2.1	267.5
SAUDI ARABIA			
Communication Products	156.4	0.0	156.4
Consumer Electronics	9.8	0.0	9.8
Electron Tubes	4.1	0.0	4.1
Electronic Parts	25.9	0.1	25.9
Computer/Industrial	158.0	0.2	157.8
Solid State Products	1.3	0.0	1.3
TOTALS	355.5	0.3	355.3
SINGAPORE			
Communication Products	166.0	509.7	-343.7
Consumer Electronics	389.5	647.7	-258.1
Electron Tubes	6.6	0.1	6.5
Electronic Parts	206.5	359.4	-152.9
Computer/Industrial	1,397.7	4,219.0	-2,821.3
Solid State Products	1,198.4	1,134.8	63.6
TOTALS	3,364.7	6,870.7	-3,505.9
SPAIN			
Communication Products	97.7	5.8	91.9
Consumer Electronics	33.8	0.9	32.9
Electron Tubes	3.3	0.0	3.3
Electronic Parts	41.1	20.9	20.2
Computer/Industrial	516.9	42.0	475.0
Solid State Products	39.5	45.1	-5.6
TOTALS	732.3	114.7	-617.7
ST. CHRISTOPHER-NEVIS			
Communication Products	1.1	0.8	-0.3
Consumer Electronics	0.7	0.0	0.7
Electron Tubes	0.0	0.0	0.0
Electronic Parts	1.3	7.4	-6.1
Computer/Industrial	1.0	0.4	0.5
Solid State Products	0.1	0.0	0.1
TOTALS	4.2	8.6	-4.3

(Continued)

TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
SWEDEN			
Communication Products	93.6	199.3	-105.7
Consumer Electronics	24.1	0.5	23.6
Electron Tubes	5.7	0.1	5.6
Electronic Parts	47.6	52.0	-4.4
Computer/Industrial	501.2	205.1	296.0
Solid State Products	31.4	13.7	17.7
TOTALS	703.6	470.7	232.8
SWITZERLAND			
Communication Products	71.2	8.4	62.8
Consumer Electronics	30.5	9.2	21.3
Electron Tubes	5.1	2.2	2.9
Electronic Parts	51.8	54.5	2.7
Computer/Industrial	609.7	211.9	397.8
Solid State Products	42.8	6.1	36.7
TOTALS	811.1	292.3	518.8
TAIWAN			
Communication Products	438.0	705.0	266.9
Consumer Electronics	119.9	778.5	658.6
Electron Tubes	33.0	86.3	53.4
Electronic Parts	139.5	922.2	782.6
Computer/Industrial	817.1	3,126.1	-2,309.0
Solid State Products	914.8	636.3	278.5
TOTALS	2,462.3	6,254.4	-3,792.0
THAILAND			
Communication Products	70.9	157.3	86.4
Consumer Electronics	68.2	367.0	298.8
Electron Tubes	1.3	1.3	0.0
Electronic Parts	23.9	49.8	25.9
Computer/Industrial	196.2	524.9	328.7
Solid State Products	516.2	378.8	137.4
TOTALS	876.7	1,479.1	602.4

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
TRINIDAD AND TOBAGO			
Communication Products	3.2	0.0	3.2
Consumer Electronics	2.3	0.0	2.3
Electron Tubes	0.1	0.0	0.1
Electronic Parts	2.2	0.0	2.2
Computer/Industrial	25.7	0.1	25.6
Solid State Products	0.2	0.0	0.2
TOTALS	33.7	0.1	33.6
TURKEY			
Communication Products	56.8	0.2	56.6
Consumer Electronics	2.8	0.0	2.8
Electron Tubes	1.3	0.0	1.3
Electronic Parts	5.1	0.1	5.0
Computer/Industrial	116.7	0.2	116.5
Solid State Products	1.5	0.0	1.5
TOTALS	184.2	0.5	183.7
UNION OF SOVIET SOCIALIST REPUBLICS			
Communication Products	5.8	0.3	5.5
Consumer Electronics	4.9	0.0	4.9
Electron Tubes	0.2	2.1	1.9
Electronic Parts	2.0	0.2	1.8
Computer/Industrial	148.2	0.2	148.0
Solid State Products	0.7	0.2	0.5
TOTALS	161.7	3.0	160.0
UNITED ARAB EMIRATES			
Communication Products	14.2	0.0	14.2
Consumer Electronics	3.8	1.1	2.7
Electron Tubes	0.0	0.0	0.0
Electronic Parts	4.0	0.0	4.0
Computer/Industrial	53.5	0.4	53.1
Solid State Products	0.6	0.0	0.6
TOTALS	76.1	1.5	74.6

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
UNITED KINGDOM			
Communication Products	568.7	175.1	393.7
Consumer Electronics	205.1	49.7	155.4
Electron Tubes	52.9	28.2	24.7
Electronic Parts	346.8	153.4	193.4
Computer/Industrial	4,211.3	1,311.5	2,899.8
Solid State Products	780.1	236.8	543.3
TOTALS	6,164.9	1,954.7	4,210.3
URUGUAY			
Communication Products	6.8	0.0	6.8
Consumer Electronics	4.2	0.0	4.2
Electron Tubes	0.1	0.0	0.1
Electronic Parts	0.4	0.0	0.4
Computer/Industrial	18.1	0.1	18.0
Solid State Products	0.3	0.0	0.3
TOTALS	29.9	0.1	29.8
VENEZUELA			
Communication Products	42.4	0.1	42.3
Consumer Electronics	33.1	1.0	32.1
Electron Tubes	1.1	0.0	1.1
Electronic Parts	16.2	11.9	4.3
Computer/Industrial	247.5	1.4	246.1
Solid State Products	6.0	0.0	6.0
TOTALS	346.3	14.4	331.9
YUGOSLAVIA			
Communication Products	8.9	0.0	8.9
Consumer Electronics	2.4	0.0	2.4
Electron Tubes	0.8	0.2	0.6
Electronic Parts	2.7	6.6	-3.9
Computer/Industrial	63.6	0.6	63.0
Solid State Products	2.3	0.9	1.4
TOTALS	80.7	8.3	72.4

Top 10 U.S. Trade Partners ($ Thousands), 1990

TABLE 7-5

U.S. IMPORTS (TOP 10 SUPPLIERS)

PRODUCT GROUP	JAPAN	SINGAPORE	TAIWAN	SOUTH KOREA	MEXICO	CANADA	MALAYSIA	WEST GERMANY	HONG KONG	UNITED KINGDOM
Communications Products	2,907,626	509,691	704,964	547,043	467,639	878,542	429,151	109,878	356,096	175,051
Consumer Electronics	9,017,546	647,678	778,460	1,641,370	1,387,632	105,309	720,309	127,791	254,306	46,679
Electron Tubes	453,311	138	86,317	14,590	51,458	14,933	5	84,016	411	28,204
Electronic Parts	1,970,474	359,384	922,152	218,474	2,144,248	1,030,266	204,481	414,051	299,169	153,426
Computer/Industrial	12,987,100	4,219,032	3,126,075	1,391,898	975,116	2,315,394	194,661	1,536,998	828,571	1,311,453
Solid State Products	3,286,093	1,134,842	636,348	1,763,195	361,051	1,006,997	1,658,088	300,602	263,400	236,843
TOTAL	30,622,150	6,870,765	6,254,316	5,576,570	5,387,144	5,351,441	3,206,695	2,573,336	2,001,953	1,954,656

U.S. EXPORTS (TOP 10 MARKETS)

PRODUCT GROUP	CANADA	JAPAN	UNITED KINGDOM	WEST GERMANY	MEXICO	SINGAPORE	NETHERLANDS	FRANCE	SOUTH KOREA	TAIWAN
Communications Products	849,836	747,786	568,729	301,394	798,045	165,976	114,175	172,531	231,023	438,043
Consumer Electronics	749,043	283,448	205,116	243,195	560,859	389,542	207,780	78,714	46,427	119,888
Electron Tubes	74,915	103,053	52,920	50,392	191,716	6,620	21,527	31,326	27,860	32,967
Electronic Parts	2,325,259	297,763	346,846	257,881	1,309,153	236,518	96,790	188,328	85,871	139,522
Compuer/Industrial	6,310,972	5,555,021	4,211,261	3,909,611	1,698,760	1,397,729	2,600,206	2,174,866	1,278,243	817,125
Solid State Products	2,159,335	1,367,479	780,118	476,088	458,889	1,198,430	141,620	411,664	1,040,571	914,829
TOTAL	12,469,360	8,354,550	6,164,390	5,238,561	5,017,422	3,369,815	3,182,098	3,057,429	2,709,995	2,462,374

SOURCE: U.S. Department of Commerce

third leading source of consumer electronics imports with an 8.5% share.

Canada replaced last year's leader, Mexico, as the number one market for U.S. consumer electronic exports in 1990, with $749 million in purchases, or 20% of the total. The top ten markets accounted for 77.5% of total consumer electronics exports in 1990.

Electron Tubes

Imports of electron tubes decreased 3.6% in 1990, totaling $822 million. Japan was once again the major source of tube imports, accounting for 55.2% or $453 million of the total. Taiwan was the second leading supplier, with $86.3 million worth of tubes sold to the U.S., followed by West Germany.

Top 10 U.S. Trade Partners by Industry Sector ($ Thousands); 1990

TABLE 7-6

COMMUNICATION PRODUCTS

	$ THOUSANDS	PERCENTAGE OF TOTALS
Total Imports	8,573,014	100.00
Japan	2,907,626	33.92
Canada	878,542	10.25
China (Taiwan)	704,964	8.22
Korea, Republic of	547,043	6.38
Singapore	509,691	5.95
China (Mainland)	488,740	5.70
Mexico	467,639	5.45
Malaysia	429,151	5.01
Hong Kong	356,096	4.15
Sweden	199,313	2.32
TOTAL	7,488,805	87.35
Total Exports	6,795,912	100.00
Canada	849,836	12.51
Mexico	798,045	11.74
Japan	747,786	11.00
United Kingdom	568,725	8.37
China (Taiwan)	438,043	6.45
Federal Republic of Germany	301,394	4.43
Brazil	254,970	3.75
Korea, Republic of	231,023	3.40
France	171,793	2.53
Israel	166,108	2.44
TOTAL	4,527,727	66.62

CONSUMER ELECTRONICS

	$ THOUSANDS	PERCENTAGE OF TOTALS
Total Imports	16,236,184	100.00
Japan	9,017,546	55.54
Korea, Republic of	1,641,370	10.11
Mexico	1,387,632	8.55
China (Mainland)	859,031	5.29
China (Taiwan)	778,460	4.79
Malaysia	720,309	4.44
Singapore	647,678	3.99
Thailand	366,976	2.26
Hong Kong	254,306	1.57
Federal Republic of Germany	127,791	0.79
TOTAL	15,801,099	97.32
Total Exports	3,747,483	100.00
Canada	749,043	19.99
Mexico	560,859	14.97
Singapore	389,542	10.39
Japan	283,448	7.56
Federal Republic of Germany	243,195	6.49
Netherlands	207,780	5.54
United Kingdom	205,116	5.47
China (Taiwan)	119,888	3.20
France	76,536	2.04
Hong Kong	70,971	1.89
TOTAL	2,906,378	77.56

ELECTRON TUBES

	$ THOUSANDS	PERCE[illegible] OF TOT[illegible]
Total Imports	821,812	100.00
Japan	453,311	55.16
China (Taiwan)	86,317	10.50
Federal Republic of Germany	84,016	10.22
Mexico	51,458	6.26
France	31,317	3.81
United Kingdom	28,204	3.43
Netherlands	19,226	2.34
Canada	14,933	1.82
Korea, Republic of	14,590	1.78
Brazil	11,289	1.37
TOTAL	794,661	96.70
Total Exports	776,471	100.00
Mexico	191,716	24.69
Japan	103,053	13.27
Canada	74,915	9.65
United Kingdom	52,920	6.82
Federal Republic of Germany	50,392	6.49
Brazil	44,859	5.78
China (Taiwan)	32,967	4.25
France	31,326	4.03
Korea, Republic of	27,860	3.59
Netherlands	21,527	2.77
TOTAL	631,535	81.33

ELECTRONIC PARTS

	$ THOUSANDS	PERCENTAGE OF TOTALS
Total Imports	8,589,113	100.00
Mexico	2,144,248	24.96
Japan	1,970,474	22.94
Canada	1,030,266	12.00
China (Taiwan)	922,152	10.74
Federal Republic of Germany	414,051	4.82
Singapore	359,384	4.18
Hong Kong	299,169	3.48
Korea, Republic of	218,474	2.54
Malaysia	204,481	2.38
United Kingdom	153,426	1.79
TOTAL	7,716,125	89.84
Total Exports	6,407,236	100.00
Canada	2,325,259	36.29
Mexico	1,309,153	20.43
United Kingdom	346,846	5.41
Japan	297,763	4.65
Federal Republic of Germany	257,881	4.02
Singapore	206,518	3.22
France	187,963	2.93
China (Taiwan)	139,522	2.18
Hong Kong	117,650	1.84
Italy	111,795	1.74
TOTAL	5,300,350	82.72

COMPUTER/INDUSTRIAL

	$ THOUSANDS	PERCENTAGE OF TOTALS
Total Imports	32,488,996	100.00
Japan	12,987,100	39.97
Singapore	4,219,032	12.99
China (Taiwan)	3,126,075	9.62
Canada	2,315,394	7.13
Federal Republic of Germany	1,536,998	4.73
Korea, Republic of	1,391,898	4.28
United Kingdom	1,311,453	4.04
Mexico	975,116	3.00
Hong Kong	828,571	2.55
Thailand	524,878	1.62
TOTAL	29,216,515	89.93
Total Exports	41,561,898	100.00
Canada	6,310,972	15.18
Japan	5,555,021	13.37
United Kingdom	4,211,261	10.13
Federal Republic of Germany	3,909,611	9.41
Netherlands	2,600,206	6.26
France	2,170,047	5.22
Mexico	1,698,760	4.09
Singapore	1,397,729	3.36
Korea, Republic of	1,278,243	3.08
Australia	1,255,533	3.02
TOTAL	30,387,383	73.11

SOLID STATE PRODUCTS

	$ THOUSANDS	PERCENTAGE OF TOTALS
Total Imports	12,183,497	100.00
Japan	3,286,093	26.97
Korea, Republic of	1,763,195	14.47
Malaysia	1,658,088	13.61
Singapore	1,134,842	9.31
Canada	1,006,997	8.27
China (Taiwan)	636,348	5.22
Philippines	566,327	4.65
Thailand	378,765	3.11
Mexico	361,051	2.96
Federal Republic of Germany	300,602	2.47
TOTAL	11,092,308	91.04
Total Exports	13,481,798	100.00
Canada	2,159,335	16.02
Malaysia	1,680,940	12.47
Japan	1,367,479	10.14
Singapore	1,198,430	8.89
Korea, Republic of	1,040,571	7.72
China (Taiwan)	914,829	6.79
United Kingdom	780,118	5.79
Hong Kong	756,017	5.61
Philippines	582,758	4.32
Thailand	516,169	3.83
TOTAL	10,996,646	81.57

Exports of electron tubes rose 13.2% in 1990. Mexico remained the principle market, taking in 24.7% of the total or $191.7 million. Japan followed with $103.1 million (13.3%).

Electronic Parts

U.S. imports of electronic parts increased 3.1% in 1990 to $8.6 billion. Mexico was the source of 25.0% of electronic parts imports, or $2.1 billion. Japan was the second leading source of imports (22.9%), followed by Canada (12.0%).

More than half of the $6.4 billion of electronic parts exported by the U.S. in 1990, went to two countries, Canada (36.3%) and Mexico (20.4%). The top ten markets accounted for 82.6% of U.S. exports in 1990.

Computer/Industrial

Trade in computer/industrial products accounted for 48.8% of total electronics trade in 1990, with over $74.0 billion worth of exports and imports crossing U.S. borders. Imports from Japan made up 40.0% of the total in 1990. As in 1989, Singapore (13.0%), Taiwan (9.6%), Canada (7.1%), and West Germany (4.7%) made up the rest of the top five. The top ten suppliers accounted for 90.3% of U.S. imports of computer/industrial products in 1990.

U.S. exports of computer/industrial products are less heavily concentrated than imports, as the top ten contributed 73.1% of the total in 1990. Canada, with 15.2% of the total, surpassed Japan (13.4%) as the leading market for computer/industrial exports. The United Kingdom (10.1%), West Germany (9.4%), and the Netherlands (6.3%) rounded out the top five markets in 1990.

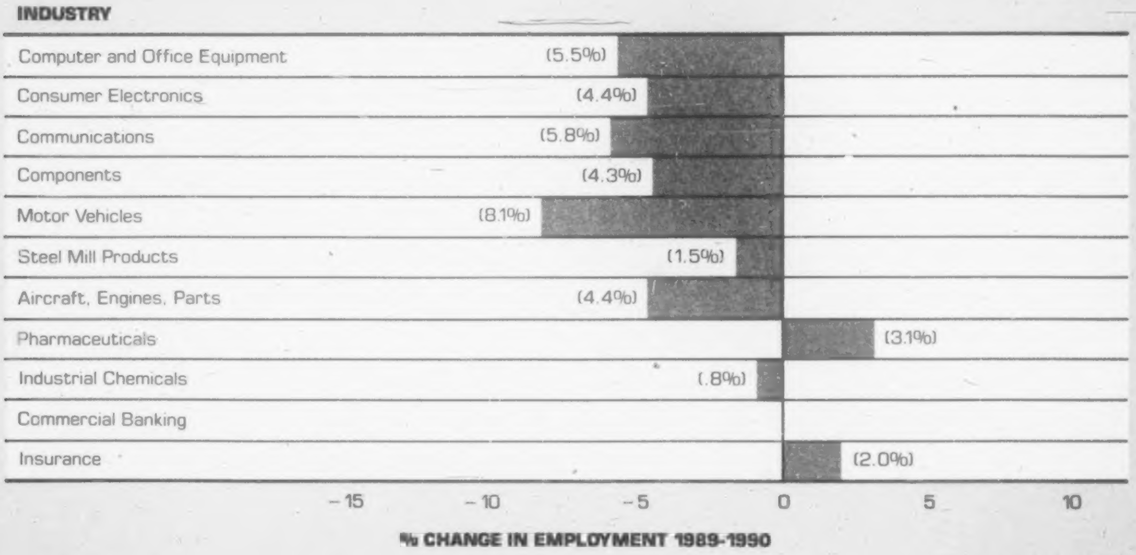
Solid State Products

U.S. imports of solid state products decreased 1.0% in 1990, to $12.2 billion. Japan supplied $3.3 billion worth of solid state products, or 27.0% of the total. South Korea (14.5%), Malaysia (13.6%), Singapore (9.3%) and Canada (8.3%) ranked second through fifth, respectively. The Pacific Rim nations accounted for more than 77.0% of solid state imports in 1990.

Solid state exports rose from $11.9 billion to $13.5 billion in 1990, an increase of 12.9%. Canada was the number one market for U.S. solid state exports, purchasing $2.2 billion, or 16.0% of the total. Malaysia, with 12.5%, placed second, followed by Japan (10.1%), Singapore (8.9%), and South Korea (7.7%). The Pacific Rim countries purchased more than half of U.S. solid state exports in 1990, making this area the dominant source of trade for the U.S. in the solid state sector.

Much of the statistical information in this chapter was gathered from the Electronic Industries Association Marketing Services Department publication *ELECTRONICS FOREIGN TRADE*. This monthly statistical journal is designed for rapid and accurate identification of import/export figures for more than 300 electronic products, listed by unit sales and dollar volume. Also featured are the trade balance data for the U.S. electronic industries by product group, plus the EIA "Top 10" list of foreign markets for U.S. electronic products, and the "Top 10" suppliers of electronic products to the U.S. *ELECTRONICS FOREIGN TRADE FIVE-YEAR SUMMARY*, also published by the EIA Marketing Services Department, provides a handy summary of much of the information found in *ELECTRONICS FOREIGN TRADE* for the most recent five-year period. For your convenience, an order form for both publications is found at the back of this book.

Comparative Employment by Industry, United States, 1989-1990 **FIGURE 7-C**



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics

EMPLOYMENT

In 1990 average annual employment in the U.S. electronic industries decreased 4.7%, (see Tables 7-7 and 7-8). All employment segments in the electronics industries declined in 1990. The components and communications segments showed the largest declines, 5.0% and 5.5%, respectively. Yet, with shifting economic prosperity across the U.S., electronic industries employment in the South Central, Southwest and California regions have been increasing at growth rates above 5%, according to Corporate Technology Information Service, Inc.

Historical trends in electronics employment compared to employment in other U.S. industries are illustrated in Figure 7-C.

Job Market Outlook

Projecting overall employment growth and the composition of the electronics workforce of the future is a difficult task. In many sectors of the industry, the restructuring that occurred during the downturn of 1986 led to a permanent loss of jobs. The move toward offshore production, brought about by the strong dollar of the mid-1980s and increased competition from the Asian NICs, also contributed to a loss of jobs, some of which may come back now that the dollar is weaker.

Economic uncertainty and currency instability make it difficult for management to project how many workers will be needed and what these workers will be doing.

Yet, amidst this uncertainty, some trends have emerged that give a number of analysts reason for optimism. One is the move toward increased automation. On the surface, automation would appear to spell doom for manufacturing jobs, as workers are replaced by machines. However, as pointed out by a number of analysts, the industry responsible for manufacturing the automation equipment is the electronics industry. According to the Congressional Office of Technology and Assessment, businesses are spending 40% of their investment dollars on computers and information-related equipment, double the share in 1978. The National Electrical Manufacturers Association's Automation Forum predicts that by 1995, 42% of industrial equipment will be automated, up from 15% in 1985. Workers will be needed to produce this equipment, install it, and repair it. More than 2.3 million *new* positions will be created by the year 2000 as a result of the move toward factory automation, according to the Hudson Institute. The workers who fill these jobs will be higher skilled and more technically-oriented than the workers of today.

The shift in the U.S. from a manufacturing to a service economy is another trend that appears to spell bad news for electronics employment, but actually is a positive movement. According to Cahners Economics, much of the future growth in the service sector will depend on the products and new technology being developed in the electronic industries. Electronic-related services will be among the fastest growing sources of new employment. The BLS projects that computer and data processing services will lead the U.S. in employment growth through the end of the century, with 4.9% annual growth.

Long-term employment projections by the BLS for various segments of the U.S. electronic industries were detailed in the November 1989 *Monthly Labor Review*. Selected projections are illustrated in Figure 7-D. The largest expansion in electronics employment is projected for the components industry. BLS estimates that employment in this industry will grow approximately 4.6% from 1990 to 2000. Employment in the computer industry (SIC 3573) is projected to expand almost 2% to 455,000 in the year 2000 from 446,300 in 1990. A total of 539,000 workers were employed in the communications industry (SIC 366) in 1990 and 542,000 are projected for 2000, a slight increase of 0.6%. An 11.8% decline is projected for employment in the consumer electronics industry (SIC 3651), from 64,600 workers in 1990 to 57,300 in 2000.

RESEARCH AND DEVELOPMENT

National expenditures for research and development (R&D) totaled an estimated $145.5 billion in 1990, up 3.6% from the $140.5 billion figure of 1989, and are forecast to reach $151.6 billion in 1991, according to the National Science Foundation (NSF).

Four principal sectors participate in R&D activities: the federal government, industry, universities and colleges, and other nonprofit institutions. As depicted in Figure 7-E, which shows national R&D expenditures between 1980 and 1991, R&D expenditures have more than doubled in the past decade, and are expected to reach $151.6 billion this year. The federal government and industry are the two prime sources of funds

Average Annual Employment in the Electronic Industries, (Thousands of Workers); United States, 1988-1990 **TABLE 7-7**

	1988	1989	1990
Consumer Electronics	62.0	66.1	64.6
Communications Equipment	591.2	570.3	539.0
Components	691.2	685.9	645.1
Computers	459.9	462.1	446.3
Industrial Electronics	243.1	249.0	242.0
TOTAL	2,047.4	2,033.4	1,937.0

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

for R&D. In 1991, these two sectors are expected to contribute 43.5% and 51.5%, respectively, toward total R&D expenditures. A scant 1.7% will be provided by nonprofit institutions and 3.3% from universities and colleges.

Industry continues to be the most important performer of R&D. In 1990 industry performed an estimated 71.6% of all R&D activities. Through use of its own funds and those from other sources, such as the federal government, industry spent more than $104 billion in R&D in 1990. The federal government performed approximately 11% of the national R&D effort in 1990, while universities and colleges performed 11%, and other nonprofit institutions, 6.3%, according to the NSF.

On the surface, the national R&D picture appears healthy, but a closer look at the numbers reveals some troublesome trends, including slower growth and a shift toward development at the expense of basic research. The growth of R&D expenditures has slowed significantly throughout the 1980s. Between 1980 and 1986, total U.S. R&D expenditures grew at a compound annual growth rate of 10.3%; since 1986 that growth rate has been almost halved to 5.0%. This declining growth rate has U.S. industry analysts concerned, as R&D spending is believed to be strongly linked to productivity growth and competitiveness.

Support from the federal government for civilian R&D projects also has declined significantly in the 1980s. According to the American Association for the Advancement of Science (AAAS), federal funding of civilian R&D has declined 24% in inflation-adjusted dollars since fiscal year 1980, while federally financed defense R&D expenditures have increased 83%. It was once widely believed that the R&D imbalance in favor of defense was justified, given private sector "spin-offs" from defense R&D projects. The validity of that theory, however,

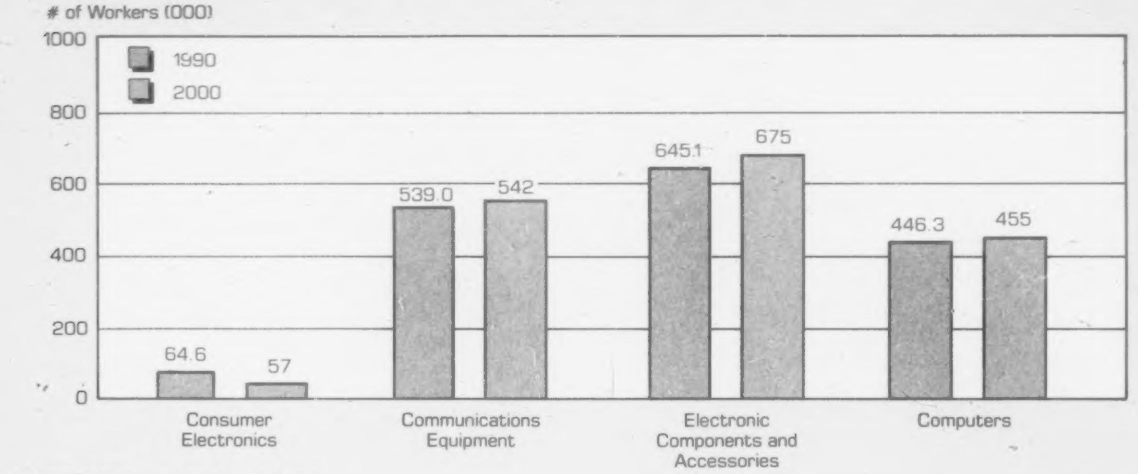
Average Employment and Earnings in the Electronic Industries, United States, 1988-1990

TABLE 7-8

	1988	1989[r]	1990[p]
Consumer Electronics			
All Employees (in thousands)	62.0	66.1	64.6
Women Employees (in thousands)	28.6	30.5	29.8
Production-Workers (in thousands)	41.6	45.3	42.8
Production-Worker Average Weekly Earnings (in dollars)	390.99	386.63	397.23
Production-Worker Average Hourly Earnings (in dollars)	9.49	9.57	9.76
Production-Worker Average Weekly Hours	41.2	40.4	40.7
Production-Worker Average Weekly Overtime Hours	3.4	3.3	3.1
Communications Equipment			
All Employees (in thousands)	591.2	570.3	539.0
Women Employees (in thousands)	225.9	217.9	206.1
Production-Workers (in thousands)	243.7	237.2	224.1
Production-Worker Average Weekly Earnings (in dollars)	495.49	515.04	535.61
Production-Worker Average Hourly Earnings (in dollars)	12.08	12.49	12.87
Production-Worker Average Weekly Hours	41.1	41.6	41.8
Production-Worker Average Weekly Overtime Hours	2.8	2.7	2.8
Computers			
All Employees (in thousands)	459.9	462.1	446.3
Women Employees (in thousands)	165.3	166.1	160.4
Production-Workers (in thousands)	148.3	146.6	140.7
Production-Worker Average Weekly Earnings (in dollars)	444.11	465.30	483.42
Production-Worker Average Hourly Earnings (in dollars)	10.65	11.00	11.51
Production-Worker Average Weekly Hours	41.7	42.3	42.0
Production-Worker Average Weekly Overtime Hours	3.0	3.3	3.1
Industrial			
All Employees (in thousands)	243.1	249.0	242.0
Women Employees (in thousands)	100.9	103.0	100.1
Production-Workers (in thousands)	127.9	132.1	126.6
Production-Worker Average Weekly Earnings (in dollars)	394.06	403.73	423.21
Production-Worker Average Hourly Earnings (in dollars)	9.52	9.82	10.27
Production-Worker Average Weekly Hours	41.4	41.1	41.2
Production-Worker Average Weekly Overtime Hours	3.0	2.8	2.9
Components			
All Employees (in thousands)	691.2	685.9	645.1
Women Employees (in thousands)	295.1	292.8	275.4
Production-Workers (in thousands)	389.4	387.2	377.3
Production-Worker Average Weekly Earnings (in dollars)	375.14	385.14	403.40
Production-Worker Average Hourly Earnings (in dollars)	9.24	9.56	10.01
Production-Worker Average Weekly Hours	40.6	40.3	40.3
Production-Worker Average Weekly Overtime Hours	3.3	3.3	3.4

p-Preliminary.
r-Revised.
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Employment in the Electronic Industries, (Thousands of Workers); United States, 1990 vs. 2000 **FIGURE 7-D**



SOURCE: U.S. Bureau of Labor Statistics

is now being questioned by a number of analysts and R&D managers, as commercial applications rarely materialized. Critics point to the recent heavy emphasis on the "development" portion of defense R&D at the expense of basic research as a major factor in the lack of commercial spin-offs. Unlike military development, which concentrates on accomplishing specialized engineering feats, basic research focuses on advancing fundamental, generic technologies applicable to a wide range of commercial markets.

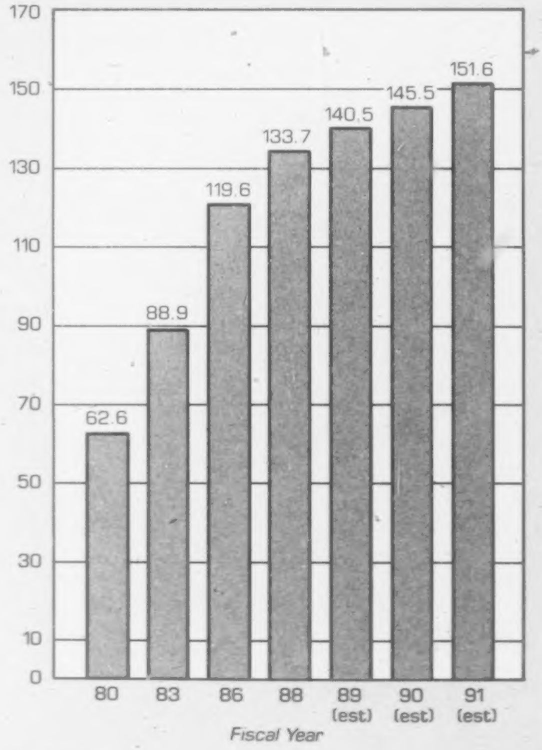
The future and composition of federally funded R&D programs are uncertain, as Congress and the administration grapple with the federal budget deficit, fears of a long recession, tight monetary policies, and the cost burden of the Persian Gulf War. Projects that focus on U.S. competitiveness as well as defense should escape any budget cuts. Congress has indicated that industry consortiums such as Sematech, the semiconductor industry manufacturers' consortium, will be supported, as will the NSF's Science and Technology Center.

Despite the worrisome trends in overall R&D spending, some encouraging developments have emerged in 1990. The R&D tax credit, which provides a 20% tax reduction to companies that increase their R&D expenditures, was renewed through the end of 1991. In his February 1991 budget message to Congress, President Bush once again proposed making the R&D tax credit permanent. A permanent R&D credit would permit taxpayers to establish and plan future research activities without the fear of the tax credit not being available when the research is performed. Policy makers across the political spectrum are promoting increased R&D spending as a necessary ingredient in regaining U.S. industrial competitiveness.

Electronics R&D

Combined federal and company funds for R&D in the electrical and electronic industries (SIC 36) totaled $16.8 billion in 1989, 3.2% more than the 1988 total, according to the latest data available from the NSF.

National R&D Expenditures ($ Billions); United States, 1980-1991 **FIGURE 7-E**



SOURCE: National Science Foundation.

Table 7-9 presents company R&D funds as well as the R&D/Sales ratio for selected U.S. electronic industries. The office, computing, and accounting machines industry (SIC 357) increased its R&D spending by approximately 50.0% between 1984 and 1989, compared to 12.4% growth from 1988 to 1989. This industry's R&D/Sales ratio is the highest overall, based on industry classifications used by the NSF. The radio & TV receiving equipment industry (SIC 365) traditionally has spent a small portion of its revenues on R&D, with company R&D funds totaling $85.0 million in 1989, a significant drop from 1988 spending of $139.0 million. The communications industry (SIC 366) increased its company R&D expenditures 14.2% from 1986 to $5.8 billion in 1989. The electronic components industry (SIC 367) topped $43.0 billion in company R&D expenditures in 1989, while its R&D/Sales ratio increased from 6.6% in 1984 to 8.3% in 1989.

The electronic industries traditionally have outperformed most U.S. industries in the percentage of revenue spent on R&D. Increased technological complexity, stiffer foreign competition and short product life cycles are frequently cited explanations for the electronic industries' commitment to R&D. In recent years, however, the rate of growth in R&D spending in the electronic industries has declined. From 1980 to 1985, R&D spending increased an average of 17.0% per year, declining to less than 7.0% a year from 1985 to 1989.

Electronics R&D spending relative to that of other major industries is depicted in Figure 7-F, which shows company R&D expenditures and R&D/Sales ratios for six leading industries. The electrical and electronic equipment industries registered one of the top R&D/sales ratios in 1989 at 5.3%.

Federal Expenditures for R&D by Agency

The federal government has been the source of nearly one-half of the total expenditures for the nation's R&D in recent years. In 1990, this percentage was 44.0%. Total federal funds obligations by agency indicate that the largest single area of R&D spending in the federal budget is defense (Figure 7-G). In 1990, R&D allocations to the Department of Defense totaled $35.9 billion, with $36.9 billion allocated for 1991, by far the largest award to any government agency. The remaining portion of federal R&D monies is largely devoted to programs in health, environment, space exploration, and energy. Currently, about 20 agencies are awarded control of segments of the total federal budget for R&D. In 1990, federal fund obligations for defense were dominated by the major players: Air Force (39.3%), Navy (27.0%), and Army (15.8%) (see Figure 7-H).

R&D Scientists and Engineers

The most recent NSF survey available estimates 1.44 million scientists and engineers were employed in the R&D field in 1988. This figure represents approximately 25.0% of the total employed scientists and engineers in the United States (Figure 7-I). Of the 2.6 million scientists employed in the U.S. in 1988, approximately 21.0% were engaged in R&D. R&D engineers comprised 33.0% of the 2.7 million engineers employed in 1988.

R&D Expenditures by Country

The relative importance that countries place on R&D can be observed by comparing R&D expenditures as a percentage of a country's gross national product (GNP). It has been effectively argued that the percent of GNP allocated to R&D is positively correlated with the level of future productivity.

During the 1960s, the United States had the highest R&D/GNP ratio of the major industrialized countries at nearly 3.0%.

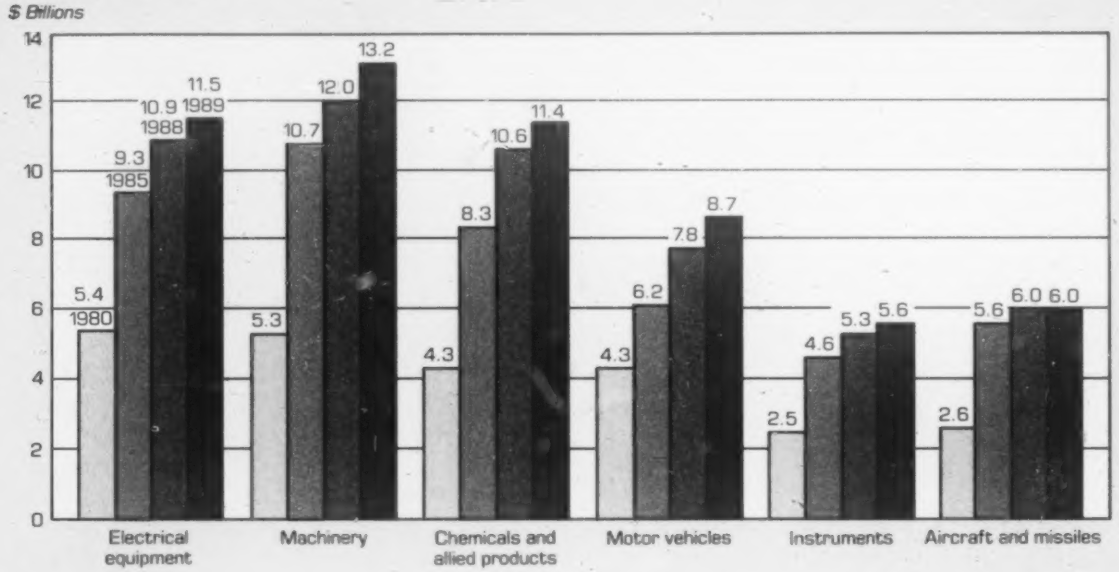
Company R&D Funds ($ Millions), R&D/Sales Ratio[1], 1985-1989 TABLE 7-9

INDUSTRY	1985	1986	1987[r]	1988[r]	1989
Office, Computing & Accounting Machines (SIC 357)					
Company R&D Funds	8,418	8,380	8,193	9,371	10,533
R&D Sales Ratio (%)	12.4	12.4	12.3	11.5	13.4
Radio & TV Receiving Equipment (SIC 365)					
Company R&D Funds	350	133	139	139	85
R&D Sales Ratio (%)	.3	3.6	3.2	3.0	2.9
Communications Equipment (SIC 366)					
Company R&D Funds	5,147	5,117	5,455	5,675	5,842
R&D Sales Ratio (%)	5.4	5.2	5.5	5.4	5.4
Electronic Components (SIC 367)					
Company R&D Funds	2,826	3,357	3,630	3,879	4,362
R&D Sales Ratio (%)	8.2	9.2	8.5	8.0	8.3

[1] Company R&D Funds as a percent of net sales.
r-Revised.
SOURCE: National Science Foundation.

Company R&D Expenditures and R&D/Sales Ratio of Six Leading Industries, ($ Billions); United States, 1980-1989

FIGURE 7-F



R&D/sales ratio

3.9% 4.8 5.2 5.3

4.5% 6.7 7.2 7.8

3.3% 4.9 5.3 5.3

4.2% 3.1 3.4 3.8

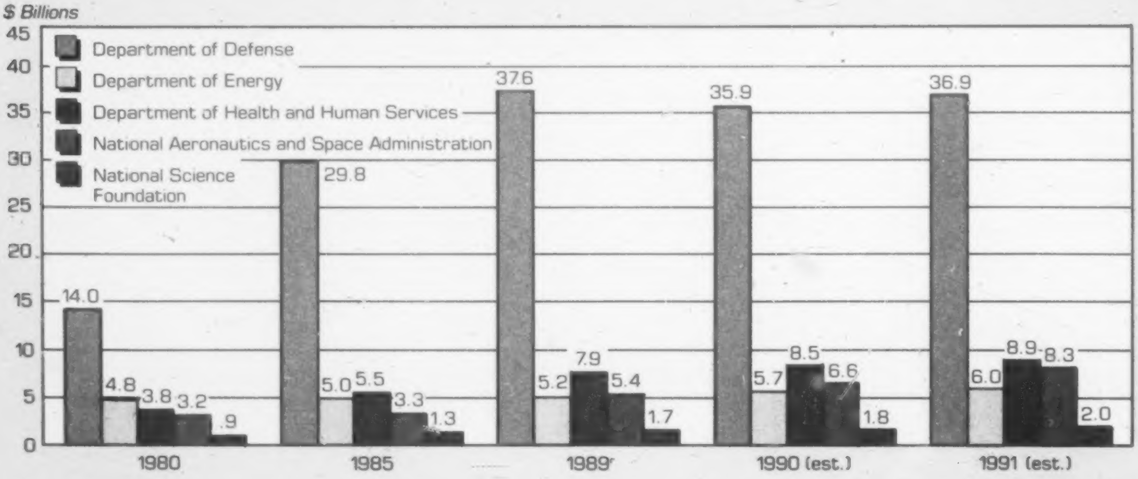
6.1% 8.3 7.3 7.2

3.8% 3.9 3.6 3.6

SOURCE: National Science Foundation

Federal R&D Obligations by Agency ($Billions); United States, 1980-1991

FIGURE 7-G



Average annual percent change

16.3% 0.8% 7.7% 0.6% 7.6%
1980-85

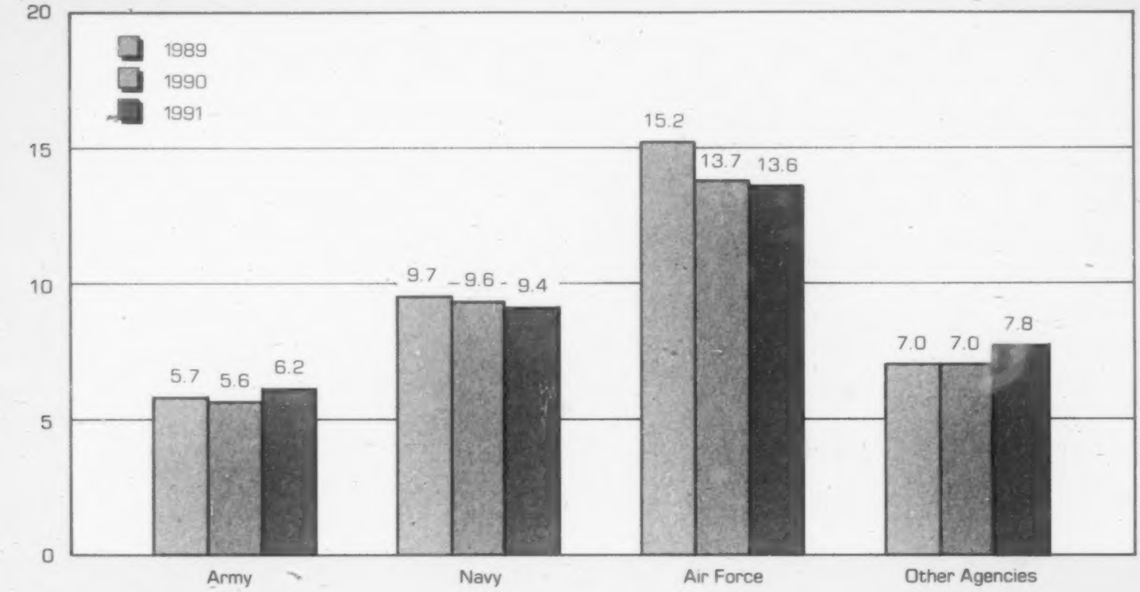
6.8% 4.3% 4.7% 9.1% 3.2%
1985-89

−4.5% 9.6% 7.6% 22.2% 5.9%
1989-90

2.8% 5.3% 4.7% 25.8% 11.1%
1990-91

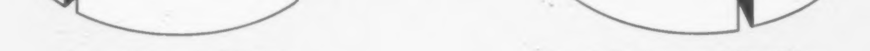
SOURCE: National Science Foundation

Department of Defense Obligations[1] for R&D by Agency, (Billions of Dollars); 1989-1991 **FIGURE 7-H**



[1]Values for 1990 and 1991 are estimates
SOURCE: National Science Foundation

Employed Scientists and Engineers by Primary Work Activity, United States, 1988 **FIGURE 7-I**



Scientists = 2.6 million

Engineers = 2.7 million

SOURCE: National Science Foundation.

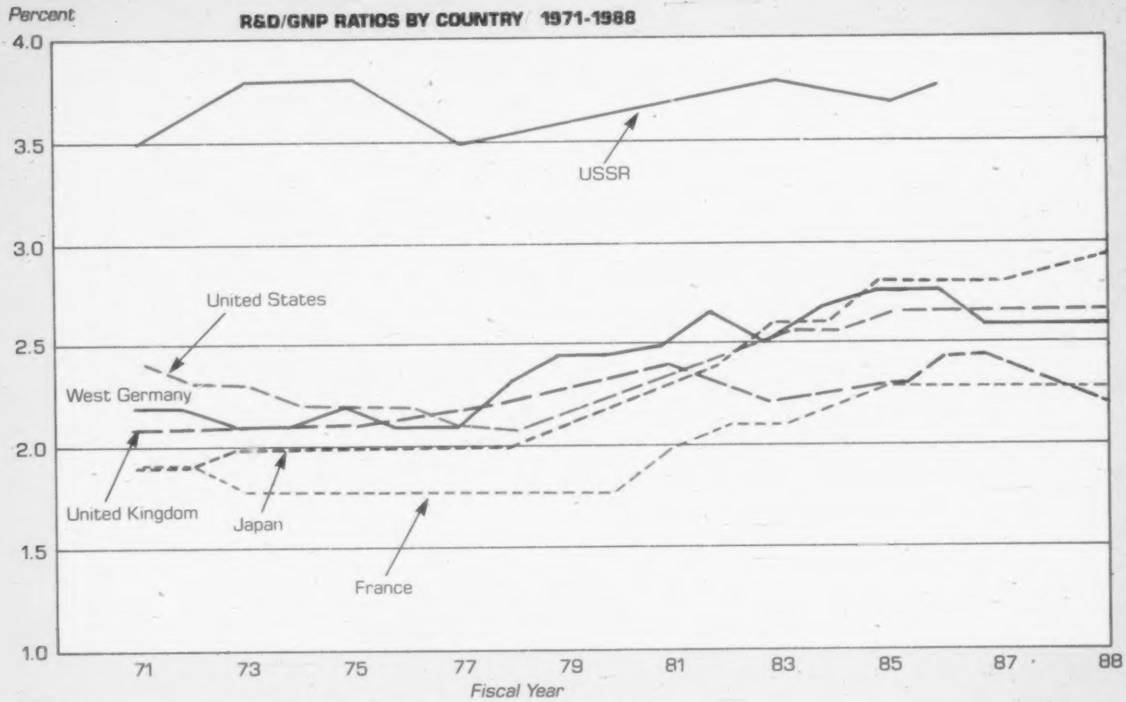
By 1971, this ratio had declined to 2.4%, while those for the U.S.S.R., West Germany, and France were increasing (Figure 7-J).

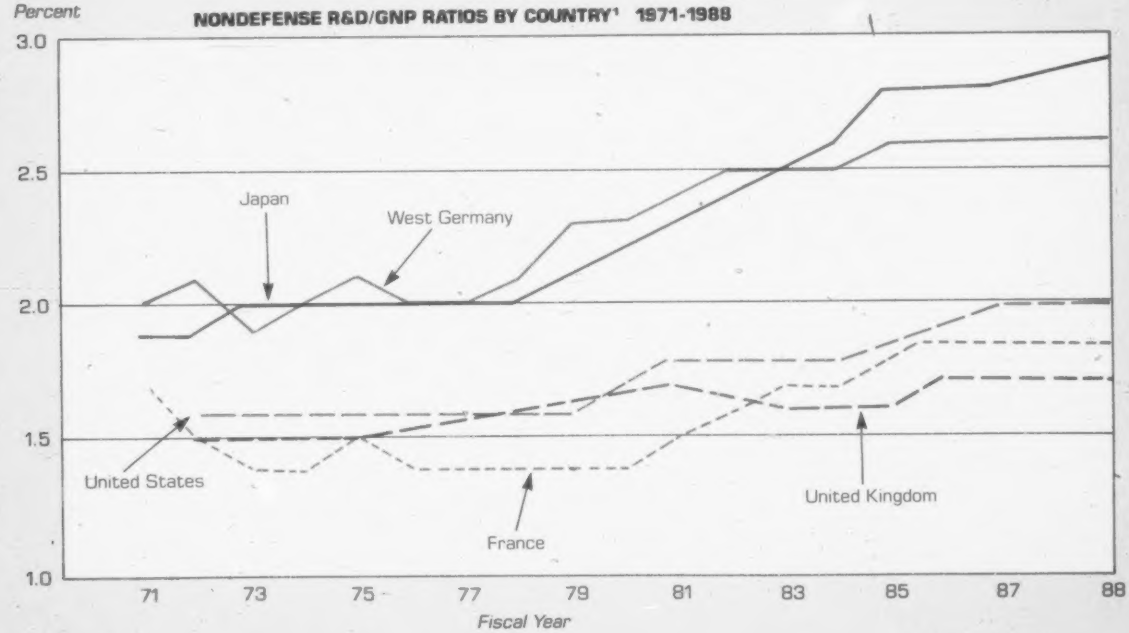
During the mid-1970s, total R&D spending by the major industrialized nations leveled off. However, in 1978 there was an upturn in total R&D expenditures for all countries shown, which has continued through the mid-1980s with the exception of the United Kingdom. From 1987 to 1988 the R&D/GNP ratios of the U.S., West Germany, and France remained flat, while that of Japan grew to nearly 3.0%.

As shown on the lower graph of Figure 7-J, nondefense R&D expenditures as a percentage of GNP indicate that the United States's historical R&D/GNP ratios are lower than those of West Germany and Japan. The United States, with its major international defense obligations, devotes a majority of government R&D funds to defense, while both West Germany and Japan are legally restricted in their defense-related R&D outlays. Consequently, in both countries, the R&D effort is primarily civilian-oriented; supporting the dominant place each country has in the world economy.

R&D/GNP Ratios by Country, 1971-1988

FIGURE 7-J





[1] Separate data for nondefense R&D in the U.S.S.R. not available.

SOURCES: National Science Foundation and Organization for Economic Co-operation and Development.

Glossary of Terms

The following glossary defines many of the acronyms and government/electronic related terminology referred to in the preceding seven chapters of the *1991 Electronic Market Data Book*.

A-B test—direct comparison of the sound/picture quality of two pieces of audio/TV equipment, by playing one and then the other.

Acoustics—the science of sound.

Acoustic (or Air) Suspension—type of loudspeaker system that utilizes an air-tight sealed enclosure.

A/D;D/A—analog to digital, digital to analog conversion.

ADIS—Advanced Driver Information System (automotive electronics).

AFC—Automatic Frequency Control: circuit which locks FM or TV receiver to station frequency. Sometimes called AFT (automatic fine tuning).

AGC—Automatic Gain Control: minimizes picture differences with changes in strength of incoming signal (TV).

AHD—Audio High Density: system of digital audio recording on grooveless discs, employing an electronically-guided capacitance pickup.

AI—Artificial Intelligence: computerized pattern recognition and logic.

All-channel tuning—ability of a TV set to receive all assigned channels: VHF and UHF, channels 2 through 83.

ALU—Arithmetic Logic Unit.

AM—Amplitude Modulation: the type of transmission used in the standard radio broadcast band, 550 to 1600kHz.

Analog—a continuously varying signal that takes the form of cycles or waves.

Analog recording—system of recording in which music is converted into electrical impulses which form "patterns" in the grooves of phonograph record masters or in the oxide particles of master tapes representing (or analogous to) musical waveforms.

ANSI—American National Standards Institute.

Anti-static—any device used to eliminate static electricity, generally associated with phonograph records.

AOI—Automated Optical Inspection: part of computer-aided manufacturing to detect errors in multi-layer PC boards.

API—Application Programming Interface (standard).

APPC/APPN—Advanced Program to Program Communication (product-independent protocol), and Advanced Peer to Peer Networking (automatic routing and directory services for a network of systems).

ASIC—Application-Specific Integrated Circuit.

ATE—Automatic Test Equipment.

ATMS—Advanced Traffic Management System.

ATV—Advanced Television System: utilizes a higher resolution than the 525 line NTSC standard.

Audio spectrum—the full range of audio frequencies, covering the lowest to the highest from 15 Hz to 20,000 Hz.

AVC—Automatic Volume Control: in radio, maintains constant sound level despite undesired differences in strength of incoming signal.

BASIC—Beginners All Purpose Symbolic Instructional Code, the most commonly used computer language. Other popular languages include Assembler, Fortran, Logo, Pascal, and Pilot.

Bass reflex—type of loudspeaker system that uses a ported enclosure.

Baud—speed at which a computer or accessory can send or receive information over telephone lines. One operating at 300 characters per second is said to have a 300 Baud rate.

Belt drive—turntable drive system whose platter is rotated by a belt attached to a motor pulley.

Beta—one of three standard VCR systems (Beta, VHS and 8mm).

Bias—in tape recording, the application of a high frequency signal to the tape to optimize its frequency response.

Bit—*Bi*nary digi*t*: a single information digit, 0 or 1, used in computers and data communications. (4 bits = a "nibble"; 8 bits = a "byte" or word). Faster machines operate in 16-bit and 32-bit configurations.

BOC—Bell Operating Companies (from AT&T split). RBOC's are Regional BOC's.

BRI—Basic Rate Interface: 144 kb/s standard rate for communications devices.

BWO—Backward Wave Oscillator: traveling wave device, used in microwave and radar applications.

CAD/CAM/CAE/CIM—Computer *A*ided *D*esign (CAD), *M*anufacturing (CAM), *E*ngineering (CAE), and Computer INTEGRATED Manufacturing.

Camcorder—A one-piece video camera and integral VCR which may or may not include a tuner.

Capstan—a flangeless pulley used to control speed and motion of magnetic tape through a recorder or playback unit.

Capture ratio—the ability of a tuner or receiver to select the stronger of two signals at or near the same frequency, expressed in decibels—the lower the figure, the better.

Carbon filter—a strong synthetic material that is low in mass with excellent damping characteristics, used in the manufacture of tonearms.

CARS—Cable Antenna Relay Services: microwave transmission systems usually used to bridge gaps between cable transmission systems.

Cartridge—device to translate (transduce) stylus motion to electrical energy in a phonograph, in three basic types—moving magnet, moving coil, induced magnet; also, tape container for automatic tape systems. A phono cartridge is also called a pickup.

Cassette—type of tape cartridge containing two reels.

CAT—Computerized Axial Tomography (as in CAT-scan); electronic scanning technique used in the medical profession, along with NMR (Nuclear Magnetic Resonance) and PET (Positron Emission Tomography).

Cathode Ray Tube—A vacuum display tube in which an electron gun generates beams that are guided to a screen illuminating small red, green, and blue phosphor targets on the surface. This results in colors and images on the TV screen/monitor.

CATV—Community Antenna TV, or Cable TV; a system of distributing TV signals.

CB—Citizens Band; the portion of the Citizens Radio Service on the 27 MHz band, used for consumer two-way communications.

CCIR—International Radio Consultative Committee; also used to describe 625-line TV system used principally in Western Europe.

CCITT—International Consultative Commission on Telephone and Telegraph; sets standards as an arm of the International Telecommunications Union.

CD—Compact Disc; a plastic disc containing a digital audio recording, which is played back, optically, on a laser-equipped player.

CD-I, CDV—Compact Disc-Interactive; stores audio, limited video, text and graphics for interactive use between a controller and a TV set. CDV (Compact Disc-Video) provides full audio/video plus text and graphics for interaction with a Personal Computer.

CD ROM—Compact Disc, Read-Only Memory; an input memory disc for computers that typically holds 550 Mbytes of data.

CEBus—The Consumer Electronics Bus is the EIA/Consumer Electronics Group (CEG) home automation standard. It allows products from different manufacturers to communicate with each other via various communication lines and transmission bridges.

CED—Capacitance Electronic Disc; system of video recording on a grooved disc, employing a groove-guided capacitance pickup. The system is no longer on the market.

CFA—Cross-field Amplifiers; part of a family of traveling wave devices, along with magnetrons, etc.

Chroma—name sometimes applied to color intensity control in a receiver.

Chrominance—portion of color TV signal representing colors.

Chromium dioxide—tape whose coating is of chromium dioxide particles; noted for its superior high frequency output.

CISC—Complex Instruction Set Computing; a power-consuming instruction format, normally used with mainframe computers. RISC (Reduced Instruction Set Computing) is the modern version used with PC's and workstations.

Circumnaural—a type of headphone that almost totally isolates the listener from room sounds.

Closed-circuit TV (CCTV)—TV system in which camera and receiver are linked by cable or microwave.

CMOS—Complementary Metal Oxide Silicon; a combination of N&P channel transistors.

Coaxial—cable in which one connector is in the center, insulation along its length from the other conductor which forms a shield outside; used for wide-band (TV) applications.

Coloration—deviation in the balance of musical sounds, audible as an accentuation of one or more parts of the audio spectrum—heavy bass, prominent mid-range, or exaggerated high frequency reproduction.

Compact System—A single manufacturer's complete sound reproduction system consisting of one main source unit and two or more separate enclosed speaker systems, packaged to sell as one unit.

Component System—A single manufacturer's complete sound reproduction system consisting of four or more separate components packaged to sell as one unit (Example: receiver, manual single-play turntable, and two speakers).

Console Television Receiver—Any television receiver with a design concept requiring placement of the unit directly on the floor without the use of an additional table, shelf, or cart; or a unit having a console design concept for standard screw-in legs; or a non-mobile base including models merchandised as console.

Continuous loop—type of tape system in which a single reel is used within an endless loop of tape.

Convergence—orientation of three electron beams in a color TV picture tube or computer monitor, so they pass through the same hole in the shadow mask at the same time.

CPE—Customer Premises Equipment; Telecommunications and computer equipment as opposed to the equipment provided by the telephone company.

CSAC—Council on Superconductivity for American Competitiveness; formed in conjunction with the Superconductivity & Competitiveness Act (PL 100-697, completed in 1989).

DAT—Digital Audio Tape; used to identify tape recorders and players as well as the tape cassettes. Digital technology is also used in storing computer data on DAT.

dB—Decibel; a measurement of two power levels. A typical use is in the "signal to noise ratio," where the higher dB level represents a higher quality of sound (freer from noise).

DBS—Direct Broadcast Satellite; a system utilizing a higher-powered satellite with smaller ground dishes.

DCS—Distributed Communications Systems; a voice/data private branch exchange (PBX), for example.

DDM—Distributed Data Management; a system of networking data control.

Degausser—device to demagnetize color picture tube for color purity.

Demagnetizer—a device that removes magnetism generated in tape heads as a consequence of playback and recording activities.

Detent tuner—manual or "click" type of TV tuner.

Digital—in displays, the use of digits for direct readout; in recording or computing, the use of a binary code to represent information; in communications, the type of information sent over lines or airwaves.

Digital Recording—a system of recording in which musical information is converted into a series of pulses that are translated into a binary code intelligible to computer circuits, and stored on magnetic tape or magnetic discs. Also called PDM—pulse code modulation.

Diode—two-element receiving tube or semiconductor device.

DIP—Dual In-line Package; an integrated circuit in which the pins are located in "line" on either side of the chip.

Dipole—antenna fed from the center; name often applied to "rabbit ear" antenna.

Direct drive—turntable drive system whose platter is an integral part of the motor assembly, and is rotated directly by the motor.

Discrete—type of quadraphone sound reproduction in which the four original sound sources are routed directly to the respective loudspeakers without encoding and decoding. Discrete is also a components term that distinguishes between an integrated circuit and an individual (or discrete) semiconductor, such as a transistor.

Display—a visual representation of electrical/mechanical functions via LED, LCD or fluorescent devices. Also called a readout.

DMTX—Digital Microwave Transmission systems.

Dolby—a system of noise/hiss reduction invented by Ray Dolby, widely used in consumer, professional and broadcast audio applications.

DOS—Disc Operating System: a controlling software for computers, such as Microsoft system (MS/DOS) OS/2, etc.

DRAM—Dynamic Random Access Memory: read/write memory in computers.

DSPT—Display Station Pass Through: allows a workstation to network as a peer with applications on other systems.

DSS—Decision Support System: modeling packages for rapid access and analysis of corporate information stores on centralized mainframes. EIS (Executive Information Systems) is a faster, more usable format for the DDS approach.

DTAD—Digital Telephone Answering Device.

DTL—Diode Transfer Logic: older component technology.

DTS—Digital Telecommunications Switching: newer digital version of switching.

Dubbing—playing a tape on one tape machine and recording (dubbing or copying) on a second machine.

Dynamic range—in music, the range of amplitudes from loudest passages to softest passages, expressed in decibels: the larger the figure, the more realistic or natural the sound.

ECC—Error Correction Code: data bits added to data streams for accuracy checking (e.g. even/odd parity check for 1's and 0's).

ECM—Electronic Counter-Measures: military use of microwave, radar (decoys).

ED-Beta—Extended Definition Beta-format VCR's. ED-Beta's separation of the luminance and chrominance signals during record and playback, a wider luminance bandwidth and the use of high density tape result in sharper, more vivid picture quality.

EDI/EDIFACT—Electronic Data Interchange/For Administration, Commerce & Transportation. A communications standard for data exchange.

EDM—Electric Discharge Machines: industrial control and automation devices.

EDTV—Enhanced or Extended Definition TV: involved advanced encoding and/or transmission techniques, but having less resolution than HDTV. Also called EQTV (Enhanced Quality TV).

EIS—see DSS.

Electron gun—device in TV picture tube, or display device, from which electrons are emitted toward the screen.

EMI—ElectroMagnetic Interference: electric, electronic or magnetic interference with signals.

EPROM/EEPROM—Erasable, Programmable Read-Only Memory: a semiconductor device whose memory can be erased by ultraviolet light (slowly) or electrically (faster).

Equalization—frequency manipulation to meet the requirements of recording: also the inverse manipulation in playback to achieve uniform or "flat" response. Also called compensation.

ESP—Electronic Still Photography: single-frame video camera recording on a disc.

ESS—Enterprise Solutions & Standards: (e.g. UNIX) an operating system to simplify changing hardware/software formats via standards, support and training.

Ethernet—a network protocol where all stations are connected to the same bus. Only one station can transmit at a time, but all can receive. (Ethernet is a Xerox trademark).

FDDI—Fiber Distributed Data Interface: a standard for 100 Mb/s transmission on Fiber Optic Local Area Networks, etc.

FEA—Finite Element Analysis: a computer aided design, manufacturing analysis of stress, thermal, magnetic, fluid flow and displacement elements.

Ferri-chrome—a tape combining a layer of ferric oxide particles and a layer of chromium dioxide particles, for the attributes of both.

Ferric Oxide—a tape whose coating is of red iron oxide: the original material used for magnetic recording tapes.

FFT—Fast Fourier Transform: a determination of the frequency content of an analog signal.

Field—one half (every other line) of a TV picture "frame": there are 60 fields per second in American TV.

Flip-flop—a digital storage device for a 0 or 1 bit.

Flops—often referred to as mega-flops or giga-flops, these are *fl*oating *op*erations per *s*econd, used to describe the speed and power of computers.

Flutter—sound distortion resulting from fairly rapid irregularities in the speed of a phonograph record or tape recording.

FM—Frequency Modulation: less susceptible to interference than AM. FM broadcast-band covers 88 to 108 MHz.

FOG-M—Fiber Optic Guided Missile: military use of fiber optic technology.

Frame—one complete television picture: there are 30 per second.

Frequency response—the total range of frequencies that can be reproduced by audio components, the wider the better. Human hearing is generally limited to the 20 to 20,000 Hz range.

Frequency synthesized tuning—tuning method that employs a reference quartz crystal oscillator for exceptional tuning accuracy—often better than .003%.

Front end—tuning, or radio-frequency, section of a radio or TV set.

GaAS, GaA/As—Gallium Arsenide/Gallium aluminum Arsenide: a semiconductor compound used in conjunction with silicon for chips.

Gate, Gate Array—an Integrated Circuit with a large number of input/output gates. Can be programmed.

GDSID—General Data Stream Identifier: used in communications systems.

GHz—see Hertz.

Graphic equalizer—a device that permits altering the tonal balance of an audio component system at several frequency levels, usually from 5 to 12.

Harmonic distortion—distortion that occurs when an audio component adds unwanted overtones to the original music tones.

HDTV—High Definition TV: High resolution TV, incorporating 1000 or more horizontal lines of resolution, wide aspect ratio and digital quality audio.

Head—The device in a recorder which makes contact with magnetic tape and converts magnetism to electrical signals or visa versa.

Hertz (Hz)—the unit of frequency equal to one cycle per second (cps): one kilohertz (KHz) = 1000 cps: one megahertz (MHz) = 1 million cps: one gigahertz (GHz) = 1 billion cps.

Home Automation—see CEBus.

Hue—color set control governing color values in TV picture. Also called tint.

IBC—Interactive Business Computer: built for networking.

IC—Integrated Circuit—a combination of interconnected circuit elements combined on a base material (e.g., silicon) capable of performing a circuit function in an extremely small size.

IDTV—Improved Definition TV: Intermediate system designed to improve resolution of existing NTSC standard without involving new transmission standard. Less resolution than EDTV and HDTV.

IEC—International Electrotechnical Commission: a group that sets standards for industrial controls. The standards apply to foreign machinery in the U.S. as well.

IF—Intermediate Frequency to which a signal is shifted within a receiver for amplification.

IM—Intermodulation (distortion) caused when both high and low frequency tones in music intermodulate with each other. Expressed as a percentage (low is better).

INA—Information Networking Architecture: networking configurations that conform to standards.

In-line—color picture tube in which the electron guns are side-by-side, as opposed to the conventional triangular arrangement.

INMS—Integrated Network Management Systems: Operating systems for entire networks of data handling and communication.

IPS—Inches Per Second: measurement of tape speed.

IR, or Infrared remote control—a system of controlling audio/visual equipment from a distance without wires. It utilizes infrared radiation to transmit the control information to a given piece of equipment.

ISDN—Integrated Services Digital Network: standards for a digital network of hardware, software, and communications links.

ITV—Instructional TV or Industrial TV.

ITSF—Instructional TV Fixed Service: a fixed station operated by an educational organization and used primarily for the transmission of audio-visual instructional, cultural and other types of material to one or more stations.

IVHS—Intelligent Vehicle Highway System: computer technology applied to automobiles and transportation systems.

JESSI—Joint European Submicron Silicon Program: an 8-year program involving private companies and governments aiming for a world-competitive status for the European semiconductor industry.

JISIA—Japan Information Services Industry Association: a software group.

JIT—"Just-In-Time" arrival of components from vendors to manufacturers. This requirement forces inventories back on suppliers, and with it, more inventory control techniques.

Kinescope—Picture tube.

LAN—Local Area Network: a connection of several computers and workstations.

Laser—Light Amplification by Stimulated Emission of Radiation.

Laserdisc Players—A device which has the ability to process digital signals from optical discs to reproduce digital video in combination with stereo sound (laser video) and may be capable of playing both digital audio compact discs and 8" and 12" laser video discs (combi-player).

Laser-optical—system of video recording on grooveless discs, employing a laser-optical-tracking pickup.

LCD—Liquid Crystal Display: a system of readout for digital watches, calculators, TV screens and computer displays using reflected (or non-reflective) light via electrical stimulation.

LED—Light Emitting Diode: a semiconductor which lights up when activated by a voltage, used in readout displays and a variety of consumer and commercial products.

Lead-in — wire or cable from antenna to TV set.

Linearity—the straightness of a frequency response curve as an indication of true or accurate sound reproduction.

Linear tracking—a straight-line movement of a cartridge/tonearm combination in certain turntables.

LISP—List Processing: an older computerized process in Artificial Intelligence.

LM—Laser Machines: used in industrial automation applications.

Low-mass—low-weight phono cartridge or tonearm (or combination of the two) devised for operation with minimal downward pressure on record grooves.

LSI—Large Scale Integration: an integrated circuit with between 100 & 1000 gates.

Luminance—brightness, or monochrome, element of broadcast color TV signal.

MAN—Metro Area Network: a company's own network, as an alternative to local carriers (telephone companies).

MATC—Master Antenna System: used in apartment building, motels, and various commercial and office environments.

Matrix—type of quadrophonic sound system in which four channels are encoded into two channels for recording or broadcast, then decoded into four channels by consumer equipment. The term is also used in displays (see black matrix).

MDA—Manufacturing Defect Analyzer: a component of Automatic Test Equipment.

Memory—device or circuit to hold machine-language in electrical or magnetic form.

MHz—see Hertz.

Micro-cassette—miniaturized version of the standard audio cassette.

Micro components—small audio components that provide the benefits of traditional-sized components in far less space.

Microprocessor—a computer element, sometimes called "minicomputer."

Midrange—speaker designed to reproduce notes between treble and bass.

MIPS—Millions of Instructions Per Second: a measure of computer speed.

MMI—Man-Machine Interface: a software and operating system and devices.

Modem—*Modulate/Demodulate*: a device that connects computers and other data transmission devices to a network (e.g., a phone line).

Monopole—single-rod indoor TV antenna.

MOS, MOSFET—Metal Oxide Silicon (as opposed to bipolar) IC's; FET = Field Effect Transistor.

MSI—Medium Scale Integration: an integrated circuit with between 13 & 100 gates.

MSS—Mobile Satellite Systems: dishes and equipment that allow vehicles to communicate with and be tracked by a central location.

MTS—Multichannel TV Sound: the initials MTS are commonly used to designate TV, VCR, and adapter tuners equipped for stereo signals. A Separate Audio Program (SAP) channel also exists for simultaneous audio (or other) use.

MTS-Capable—A television receiver or VCR with a built-in MTS (multi-channel television sound) decoder, whether for stereo sound and/or second audio channel.

Multiplex—Superimposition of two separate signals on a single broadcast channel (as in FM stereo) or on a single wire/cable for data transmission.

MYP—Multi-Year Procurement: a purchasing procedure used by the government that often applies to government electronics systems.

NAMSRC—National AM Stereo Radio Committee.

NATA—North American Telecommunications Association.

Negative guardband—color picture tube in which holes in the shadow mask are slightly enlarged and phosphor areas slightly reduced, insuring that each phosphor area is fully illuminated by the electron beam for greater brightness.

Negative Matrix—combination of negative guardband and black matrix.

NICs—Newly Industrialized Countries.

NLOS-FAAD—Non-Line Of Sight Forward Area Air Defense: on-board Fiber Optic system for guided missiles (see FOG-M).

NMR—Nuclear Magnetic Resonance: medical electronics used for diagnosing and monitoring diseases without X-rays.

Node—a central switching system that routes information from original points to destinations in LANs, etc.

NTSC—National Television System Committee: applied to U.S. systems of color and monochrome TV broadcasting.

OCR—Optical Character Recognition: devices used in scanning, image processing and text recognition.

OEM—Other Equipment Manufacturer: buyers of components for their own assembly. Also buyers/providers of finished goods for different marketers.

OLTP—On-Line Transaction Processing: electronic banking, for example.

Open-air—type of stereo headphone that offers "private" listening capability but does not totally shut off sounds within the listening room.

OSI—Open Systems Interconnect: a protocol model promoted by International Standards Organization (ISO).

OSS—Operating Support Systems: software support for networks.

PAD—Packet Assembler/Disassembler: a converter for transmitting bundles or packets of data. The generally accepted protocol is X.25.

PAL—Phase Alternate Line: Color TV system adopted by most Western European countries. In Components, PAL stands for Programmable Array Logic. The device that contains the logic is called a PLA (Programmable-Logic Array).

PAM—Plasma Arc Machines: part of a family of industrial automation machines.

PBX—Private Branch Exchange; the company premises telephone switching equipment.

PCM—Pulse Code Modulation: the binary version of an analog signal.

PDS—Premises Distribution System: local networks for voice/data.

Phosphor—substance that glows when struck by electrons, used to coat the inner surface of a picture tube.

Pitch control—variable control for increasing or decreasing the speed of a tape deck or turntable. "Pitch" is also a measurement of picture tube internal tolerance.

Pixel—Picture (pix) Element: the smallest point in a display.

PLC—Programmable Logic Controller: used in industrial controls.

PMA—Physical Media-Dependent: a standard for communication interface.

Polyamide, polymer, polypropylene—synthetic materials used for speaker cones, noted for light weight, minimum resonance, and the proper elasticity-rigidity for fast transient response.

Preset—the "programming" of radio station frequencies in a tuner or receiver, or musical selections on tape, for instant recall at the push of a button.

PRI—Primary Rate Interface: a communications integrated system standard (1.544Mb/s) for transmission.

Projection Television—Any indirect-view television receiver. Unless otherwise specified, projection television is not included in color television statistics.

PROM—(one-time) Programmable Read-Only Memory: to store digital codes.

PSTN—Public Switched Telephone Network: Telco network.

RAM—Random Access Memory: used by a computer to store and manipulate information.

RBOC—Regional Bell Operating Company.

RDT&E—Research, Development, Technology and Engineering: a government budget category that is closely related to the electronics industry.

Remote Control—A device which permits controls of electronic equipment from a distance.

RF—Radio Frequency.

RISC—Reduced Instruction Set Computing: a standard language for PC's and workstations in networks.

RMS—Root Mean Square: method of measuring amplifier power.

ROM—Read-Only Memory: media pre-programmed with information. A computer's built-in ROM contains operating instruction. Plug-in ROM cartridges are used in video games, and Compact Discs include ROM for input into computers.

SAP—see MTS.

SCSI—Small Computer Systems Interface: a standard for disc drive/controllers.

SDLC—Synchronous Data Link Control: standard interface between LANS and wide-area networks (WANS).

SECAM—Sequential and Memory color TV system adopted by France and other Eastern European and Middle East countries.

Selectivity—ability of a tuner or receiver to select a desired station while rejecting other adjacent stations. The higher the decibel-reading, the better the selectivity.

Self-healing rings—fiber optic loops that help protect against telecommunication network breakdowns: used in MANS.

Sensitivity—the input signal level required by a tuner, amplifier, etc., to be able to produce a stated output. The lower the necessary input, stated in MV (microvolts), the higher the sensitivity.

Separation—extent to which two stereo channels are kept apart: expressed in decibels: the higher the number, the better the separation and stereo effect.

Shadow mask—color picture tube in which the electron beam is directed through a perforated metal mask to the desired phosphor color element. Two similar perforations are the slits and slots, as opposed to round holes.

Shibata—stylus tip for playback of discrete four-channel records.

SM, SMD, SMT—Surface Mount, SM Devices, SM Technology: a miniaturization technology of soldering directly to copper pathways on PC boards without holes, wires, or leads.

SMART—Surface Mount & Reflow Technology: the technology of interconnecting and packaging electronic circuits. EIA and IPC (Institute for Interconnecting and Packaging electronic circuits) holds "SMART" conferences to advance standards.

SMRS—Specialized Mobile Radio Systems.

S/N—Signal to Noise ratio: ratio between a component's output signal intensity and its accompanying noise content. expressed in decibels—the larger the number. the better.

SNA, SNADS—System Network Architecture. SNA Distribution Services.

Solid-state—commonly used to indicate use of semiconductor devices vs. tubes.

SONET—Synchronous Optical Network: a standard for Fiber Optic and optic-related equipment.

SPARC—Scalable Processor Architecture.

SPL—Sound Pressure Level: loudness level of a speaker relative to a specified output signal. stated in decibels.

SRAM—Static Random Access Memory: power-dependent digital storage.

SSI—Small Scale Integration: IC chips with 1-12 gates.

S-VHS—Super VHS: separation of the luminance and chromanance signals. a wider luminance band width and the use of high density tape provide 400 lines or better. compared to 240 lines (resolution) of a standard VHS VCR.

T1, T3—Time division multiplexer links: T1 integrates voice. data video. fax. and graphics in a 1.5 mb/s speed: T3 (DS3) sends at a 45 mb/s rate.

TAD—Telephone Answering Device.

Tangential tracking—straight-line movement of a tonearm tangent to the grooves.

TCP/IP—Transmission Control Protocol/Internet Protocol: two protocol standards for sending and connecting data systems.

TCE—Thermal Coefficient Expansions.

TDM—Time Division Multiplex: backbone network for volume data transmission.

TENS—Transcutaneous Electrical Nerve Stimulation: Medical electronic technology.

THD—Total Harmonic Distortion: harmonic distortion created by an audio component. expressed as a percentage—the lower the better.

Time delay—audio circuitry that provides a delay before initiating an output signal to create an acoustical result. e.g., a "studio" or "concert hall" ambience.

Token, Token Ring—the bit pattern of a ring network to determine if transmission ring is free or busy.

Transducer—a device that converts one type of energy (electrical. acoustical. magnetic. mechanical) into another.

Transistor—active semiconductor device with three or more electrodes.

TRON—The Real-Time Operating Nucleus: a Japanese standard operating system for connecting various micro systems into a network.

TT&C equipment—Tracking. Telemetry and Control equipment used to manage satellite communications.

TTL—Transistor to Transistor Logic: back to back bipolar transistors (high speed).

Tuner—portion of a radio or television set to select the desired incoming signal.

TVRO—TV Receive-Only: typically. a large satellite dish.

Tweeter—a high frequency (treble) loudspeaker.

Twin lead—standard 300 ohm TV or FM lead-in wire (ribbon).

TWT—Traveling Wave Tubes: continuous wave devices for microwave. radar uses.

UHF—Ultra High Frequency: TV channels 14 through 83.

UPS—Uninterruptible Power Supply: back-up protection for computers and communications systems.

VAN—Value Added Networks: services provided to enhance LAN links. usually where nodes are more than 200 miles from the central headquarters.

Varactor—Variable-capacitance diode used in electronic tuning systems for TV and radio: hence the name "varactor tuning."

Vernier tuning—continuous-type fine tuning.

VGA—Video Graphics Array: a computer and monitor display designed for graphics.

VHD—Video High Density: system of video recording on grooveless discs. employing an electronically-guided capacitance pickup. (Not in U.S. market now).

VHF—Very High Frequency: TV channels 2-13.

VHS—Video Home System: one of the standard home VCR systems (Beta. VHS. 8mm).

VHSIC—Very High Speed Integrated Circuit.

Videocassette—video tape package in cassette or cartridge form.

Videocassette Player (VCP)—A magnetic tape device that can play. but not record. videocassettes.

Videocassette Recorder/VCR Deck—A magnetic tape recording device which-records both video and audio information simultaneously on one magnetic tape cassette. with an integral. inseparable television tuner.

VLSI—Very Large Scale Integration: IC chips with 1000 or more gates.

VSAT—Very Small Aperture Terminal: ground station equipment for point-to-multipoint and other combinations of satellite communication applications.

VTR—Video Tape Recorder: Broadcast use may involve reel-to-reel devices.

VU meter—Volume Unit indicator used to show volume level in tape recording. Also has industrial applications.

WAN—Wide Area Network: communication network designed to cover a large geographic area. often linking LANs.

Wireless cable—microwave transmission of television programming.

Woofer—low frequency (bass) loudspeaker.

WORM—Write Once. Read Many: optical disc for storing data (record. but not erase).

Wow—sound distortion resulting from slow irregularities in the rate of speed of a record or tape recording.

EIA: Serving the Electronic Industries

The Electronic Industries Association (EIA) is the full-service national trade organization representing the full spectrum of electronic manufacturers in the United States. Its members range from manufacturers of the smallest electronic part to corporations that design and produce the most complex systems used in defense, space and industry.

Originally founded in 1924 as the Radio Manufacturers Association, EIA, through its 67 years of service to the electronic industries, has maintained a quick reaction capability to recognize problems which are common to the industry or segments of the industry, and to mount action programs leading to the solution of these concerns. Because of its broad representation and its reputation for constructive action, EIA is nationally recognized as the spokesperson for the electronic industries.

Membership

EIA membership is open to all firms manufacturing electronic products in the United States. Certain other organizations may be admitted as Associate Members.

Administration

Broad EIA policy is established by a Board of Governors whose members are elected by the various Divisions of the Association. The EIA Executive Committee oversees programs delegated to it by the Board. An experienced professional staff of about 140 persons, headed by a salaried President, serves EIA from a headquarters building located in Washington, D.C., four blocks from the White House.

Organization

Organized along product lines, EIA's Groups/Divisions are the action centers around which most of the Association's work revolves. They provide the concentrated and specialized attention required by the issues facing the electronic industries, particularly the interface with legislative and regulatory bodies on the federal and state levels. Each Group/Division has its own mandate and objectives, its own Board of Governors, and initiates its own agendas. Each implements its own activities to meet the needs of its industry. Association members may belong to as many Groups/Divisions as appropriate to their product lines. Groups/Divisions include: Consumer Electronics; Industrial Electronics; Components; and the Government Division.

EIA Departments provide services in marketing statistics and other data, engineering standards, legislative and regulatory information, government relations, and public affairs. Services and programs of a broad nature which benefit the entire industry are also provided to the EIA membership through Board of Governors-sponsored programs. The services of all EIA Departments, Councils and Panels, as well as the administrative, legal, accounting and production services of the Association, are accessible to each Division.

Division Membership Dues

Companies join one or more Divisions of EIA, depending on their electronic product lines. Division dues are assessed as a small percentage of the annual sales value of these products for the preceding year. These dues, which are decided upon by the Division membership, are used to defray Division operating expenses, including Engineering and Marketing Services Department programs.

Basic Membership Dues

Each company is also assessed Basic dues, calculated in the same manner as Division dues, to support the Basic Services provided by the many Board-sponsored Councils, Panels and Committees which carry on EIA-wide programs of benefit to all members. Basic dues are also used for Association overhead and general and administrative expenses.

Meeting Activity

EIA holds two Association-wide, four-day conferences each year: In the spring in Washington, D.C., where the emphasis is on government relations; and in the fall on the West Coast. Most of the detailed work of the Association is conducted by more than 500 Councils, Panels, Sections, and Committees. These groups meet as necessary throughout the year, but carry on much of their activity by mail in order to minimize participation costs for members.

Information Programs

EIA provides its members with a wealth of information through regular publications and numerous special bulletins, memoranda, analyses and reports. These include various federal agency dockets as well as other federal regulatory and legislative proposals; analyses of military, space and other government budgets; and statistical marketing reports. EIA basic publications include:

- Annual Report
- Electronic Market Data Book
- Electronic Market Trends
- Electronics Foreign Trade
- Engineering Report
- Executive Report to the Electronic Industries
- Index of EIA and JEDEC Standards and Engineering Publications
- Publications Index
- Source and Date Code
- Trade Directory

Membership Options

There are many membership options available to prospective member companies, such as sizeable introductory discounts for the first two years of membership, and the option of having only parts of a company belong to a Division of EIA. Further information on membership options, dues schedules and participation in EIA, should be requested from the Office of the Secretary, EIA, 2001 Pennsylvania Avenue, N.W., Washington, D.C. 20006-1813.

EIA MEMBERSHIP PROVIDES:

- **Government Agency Liaison**—EIA maintains close liaison with the rising number of government agencies—both defense and civil—which interface with the electronic industries. EIA develops and presents industry consensus views and recommendations as these agencies develop regulatory policy, regulations, and standards. Our primary goal is seeing that such government activity is reasonable as well administratively and technically feasible.
- **Congressional Liaison**—EIA monitors legislative activity having potential impact on the electronic industries and develops and presents testimony when congressional public hearings are scheduled. EIA is recognized by Congressional Committees as the spokesperson for the electronic industries.
- **Market Data**—EIA's in-depth marketing statistics provide information of great value for market planning by industrial companies.
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- **Media Liaison**—EIA is the recognized information authority, in constant touch with national and trade press on current industry issues and queries.

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The EIA Marketing Services Department has long been recognized as THE AUTHORITATIVE SOURCE for statistical and analytical market information on the electronic industries. Information is provided through market activity reports, surveys and special reports, publications, the Marketing Services Research Center, market analysis, and liaison activities with the government and other associations. The main function of the EIA Marketing Services Department is as a service arm, supplying statistical information to the EIA membership. The Department remains committed to developing new services and improving its current ones in an effort to meet the market information requirements of the fast-changing electronic industries.

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- Import statistics for articles traded under Generalized System of Preferences (GSP) by product group.

Electronics Foreign Trade Five-Year Summary

A compilation of year-end statistics from EIA's monthly publication. Featured are import and export data for more than 300 electronic products, covering the most current five-year period.

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The monthly Marketing Services Research Center newsletter is designed to keep its readership abreast of the Center's activities and new electronic industries information resources. **Update** reports on new market research, provides information on new technologies and industry trends, annouces the Research Center's latest inquiries, and offers a special statistical "Economic Data Bank."

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